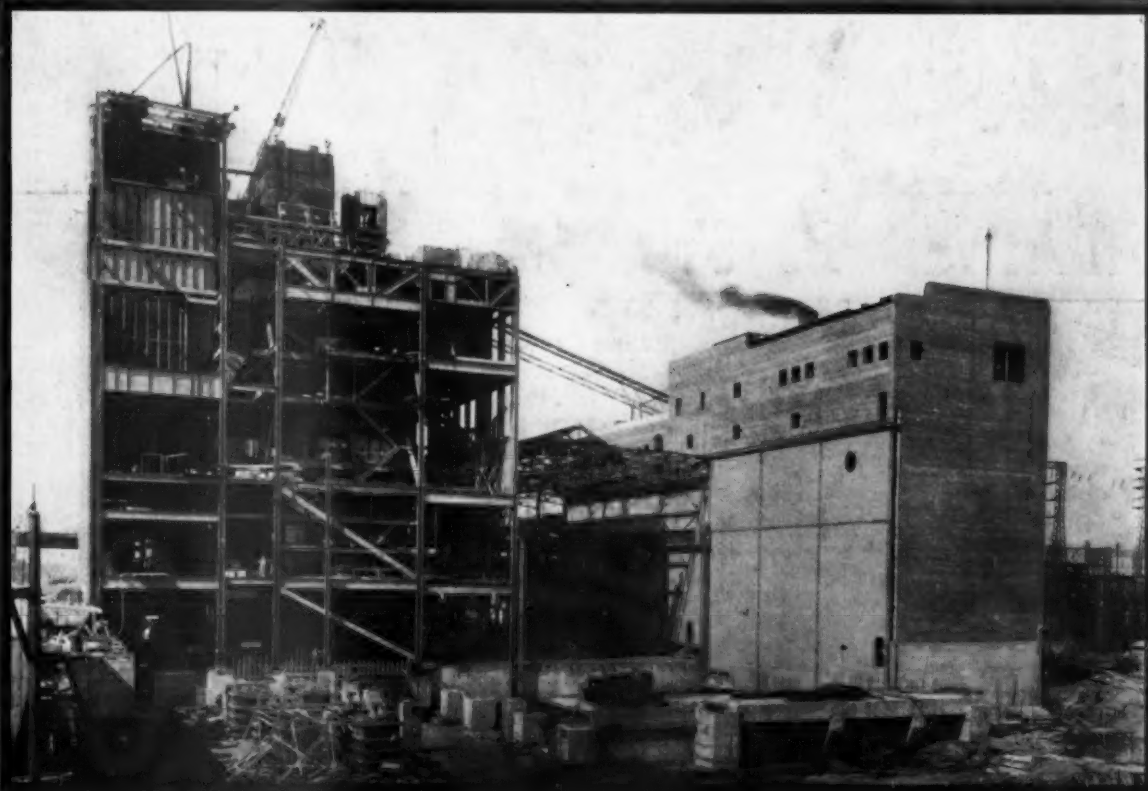
COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

October, 1941



Construction view of Venice Plant No. 2 with boiler house at left; for description see page 46

X-Raying at a Million Volts ▶

Venice Plant No. 2 ▶

Combustion Calculations—Coke-Oven Gas ▶

COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

VOLUME THIRTEEN NUMBER FOUR

CONTENTS

FOR OCTOBER 1941

FEATURE ARTICLES

EDITORIALS

DEPARTMENTS

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Steel Company	3rd Flowmatic Order	1	Freyn	130	25,000	1937	3
Industrial Plant	2nd Flowmatic Order	2	B & W	160	60,000	1941	3
Steel Company	2nd Flowmatic Order	1	B & W	165	50,000		
	3rd Flowmatic Order	1	B & W	165	50,000	1939	3
Steel Company	2nd Flowmatic Order	2	Vogt	165	35,000	1941	3
Steel Company	4th Flowmatic Order	1	B & W	175	40,000		
	5th Flowmatic Order	2	Badenhausen	175	125,000		
	6th Flowmatic Order	1	B & W	175	40,000		
	7th Flowmatic Order	1	B & W	175	40,000	1938	10
Steel Company	2nd Flowmatic Order	1	Erie City	200	100,000		
	3rd Flowmatic Order	1	B & W	200	25,000	1940	6
Paper Mill	2nd Flowmatic Order	1	C-E	220	100,000	1941	2
Steel Company	2nd Flowmatic Order	1	F W	250	105,000	1940	2
Steel Company	2nd Flowmatic Order	2	B & W	350	300,000	1940	4
Oil Refinery	4th Flowmatic Order	1	Kellogg	390	72,000	1937	9
Navy Yard	2nd Flowmatic Order	1	Riley	405	165,000		
	3rd Flowmatic Order	2	C-E	405	150,000	1940	4
Chemical Company	3rd Flowmatic Order	1	Riley	420	300,000	1938	6
Paper Mill	2nd Flowmatic Order	1	C-E	450	110,000		
	3rd Flowmatic Order	1	B & W	450	200,000	1940	16
Synthetic Textile	4th Flowmatic Order	1	Riley	600	300,000	1938	6
Synthetic Textile	2nd Flowmatic Order	1	B & W	620	180,000	1941	2
Public Utility	2nd Flowmatic Order	2	F W	650	250,000	1940	3
Oil Refinery	3rd Flowmatic Order	1	Riley	650	125,000	1939	3
Munitions Plant	2nd Flowmatic Order	1	Riley	675	150,000	1937	3
Munitions Plant	2nd Flowmatic Order	2	Badenhausen	150	30,000		
		1	Badenhausen	700	45,000	1941	12
Munitions Plant	2nd Flowmatic Order	1	Riley	725	125,000	1937	3
Public Utility	3rd Flowmatic Order	3	B & W	865	433,000		
	4th Flowmatic Order	3	B & W	865	550,000	1940	10
Public Utility	6th Flowmatic Order	1	F W	875	550,000	1937	7
Public Utility	2nd Flowmatic Order	1	Riley	900	300,000	1940	2
Public Utility	2nd Flowmatic Order	1	B & W	900	450,000	1940	2
Public Utility	2nd Flowmatic Order	1	C-E	975	500,000	1940	8

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EDITORIAL

Coal Rate Per Kilowatt-Hour Continues Downward

According to a report recently released by the Federal Power Commission, the consumption of fuel, in terms of coal and coal equivalents, for the production of electricity during 1940 averaged 1.35 pounds per kilowatt-hour of net station output for all the electric utilities. This represents the lowest figure on record and compares with 1.39 pounds for the year 1939. Undoubtedly, the high efficiency of new plants and extensions placed in service last year contributed in part to this excellent showing, as did also the higher plant capacity factors under which many were operated. Furthermore, the number of stations capable of turning out a kilowatt-hour on less than a pound of coal is constantly increasing and this tends to bring down the average for the country.

To what extent, if any, the very considerable amount of new capacity placed in service during the present year, combined with sustained high plant factors, will tend further to lower the figure for 1941 is somewhat speculative; for in the present emergency, which calls for all available capacity, loading schedules must be dictated by considerations other than efficiency and much older and less efficient equipment must be put to use. Also, as defense demands tighten, many plants may find it difficult to procure the particular coal best suited to most economical operation. Finally, under present conditions rehabilitation for economy has little chance in these days of priorities unless tied in with defense. This in some cases may place additional capacity in locations other than those having greatest economic possibilities.

It is a big drop from an average of 3.39 pounds per kilowatt-hour in 1920 to the latest figure of 1.35 pounds, which serves as a tribute to the engineering skill that has gone into the design and operation of power plants over the past twenty years. This in itself may be regarded as a most important factor in defense, for were the 1920 economy figure applied to the present total electrical output of the country the coal demand would be such as to place a burden on both mining and transportation facilities.

X-Raying as an Aid in Defense Work

The medical profession was the first to appreciate the value of X-rays in diagnosis and as an indispensable aid in setting fractures. Dentistry soon followed in adopting it as a working tool. Industry, however, appears to have been slow in sensing its possibilities and, excepting some important pioneer work carried on in one of the Government arsenals and some investigations in the aluminum field, it was not until about a decade ago that mechanical engineers, seeking an indestructible test for the increasing applications of welding, hit upon radiography as a solution to the problem. Accordingly, it was prescribed for the examination of welds in fired pressure vessels. Since then it has been widely applied to the examination of castings of all kinds and its use has spread to numerous other fields including food processing in which fluoroscopy is involved. Employing relatively low voltage, it is now being used extensively in micro-radiography for examining very thin materials.

The present defense program has given an added impetus to X-raying as a tool of inspection and the number of people becoming conversant with its use is greatly increasing—so much so that it is likely to achieve a permanent and diversified place in post-war industry.

It was enlightening to those attending the recent Symposium at Schenectady to learn not only of the expanding applications of radiography but also of the development work leading to the use of extremely high voltages. Employment of a million volts in radiography, aside from affording greater definition for the detection of flaws, is of inestimable value in speeding up inspection both through lessening exposure time and rendering necessary fewer exposures because of the greater focal length. The compactness and flexibility of the new equipment is also a factor in this respect. Its present availability after four years of intensive development is most timely in view of defense demands.

Important as is the million-volt machine one should not infer, however, that it will displace those operating at lower voltages, except for the examination of plates above a given thickness, heavy castings and in mass production where a number of objects are to be radiographed at the same time. In many fields the lower voltages will continue to serve important uses.

Tanker Construction

In announcing awards for the construction of 49 additional tankers the Maritime Commission states that, including 62 now being built under private contract for individual operators, 97 scheduled and building under the Commission's program and 360 now in operation, the total will reach 568 oil carriers. According to the latest available figures Great Britain now has 432 vessels of this type.

Making allowance for possible sinkings and bearing in mind that transportation of oil by tankers costs very much less than by pipe-line pumping, this array of tankers would appear to eclipse Mr. Ickes' argument for the construction of a large pipe line from Texas to New Jersey, especially when it is considered that most of the tankers will have been in service before such a pipe line could be completed. While this has little bearing on the present oil situation, the post-emergency economics are apparent.

X-RAYING AT A MILLION VOLTS

Fig. 1—Lowering a large turbine casting through the roof of the G. E. X-Ray Laboratory preparatory to radiographing with a million volts

DISCUSSED AT SYMPOSIUM

A SYMPOSIUM on X-raying with one million volts was held at the General Electric Company, Schenectady, on October 7 before a group of about twenty-five industrial and business paper editors, many of whose respective fields are employing X-ray examinations in connection with defense work as well as with commercial products. Contributing to the symposium were papers by representatives of the General Electric Company, the General Electric X-Ray Corporation, Combustion Engineering Company, Babcock & Wilcox Company and the Ford Motor Company—users of such equipment.

Following presentation of the papers, an inspection trip of the G. E. Works Laboratory enabled the guests to examine the new equipment and to witness its operation in connection with the examination of large castings.

At an informal dinner in the evening brief talks were given by Dr. W. D. Coolidge, Director of the G. E. Research Laboratory, W. S. Kendrick, Vice President of the General Electric X-Ray Corporation, R. S. Peare and W. L. Merrill of G. E. These speakers reviewed the vast amount of research and development, requiring the full time of six men for four years, leading up to the practical application of a million volts. It was also pointed out that while radiology in the medical field had far outstripped its use in industry following the last war, because medical men had been forced to adopt it, now, with a gigantic production program under way for defense, impetus has been given to the employment of X-ray not only for the examination of metals but in a great variety of other ways. It was predicted that these lessons learned in time of emergency will later be put to excellent use in the production of new, better and cheaper peacetime products.

The story of million-volt X-rays, their applications and possibilities, was told jointly by **Dr. E. E. Charlton** and **W. F. Westendorf** of the G. E. Research Laboratory in their papers at the symposium. In contrast with special 800,000-volt medical X-ray equipment built a few years ago, which required a special multi-story building, the present million-volt unit as designed for industrial use is less than five feet high, three feet in diameter and weighs about 1500 lb. This has been rendered possible (1) by the employment of Freon gas under pressure as an insulating medium in place of oil; (2) by the development of a resonance transformer without an iron core; and (3) by employing a multi-section X-ray tube inserted in the center of the high-voltage coil; see Fig. 2. The power required to operate the machine is approximately four kilowatts. Moreover, it is portable within the limits of a room constructed to prevent the escape of stray radiations and is susceptible of being mounted so as to take radiographs at any angle and of being inserted horizontally within a pressure vessel, thus minimizing the number of exposures and the consequent time involved.

Five-inch steel plate can be radiographed in about five minutes with million-volt X-rays at a focal distance of 48 in., whereas with 400,000 volts, the previous highest available voltage for industrial work, $2^1/_2$ hr were required at a focal distance of 32 in. A three-inch plate requires $2^1/_2$ min with 400,000 volts and only 48 sec with a million volts.

Donald McCutcheon of the Ford Motor Company discussed the rôle of the million-volt machine in speeding up defense production. This he illustrated by pointing out that in tests conducted on a heavy part destined for a large bomber, a minimum of six exposures per casting are required with a 400,000-volt machine, but the million-volt unit is capable of X-raying the entire castings at one exposure. Direct comparisons of films on identical castings containing small defects were made with the 400,000-volt unit and the million-volt unit. The superiority of

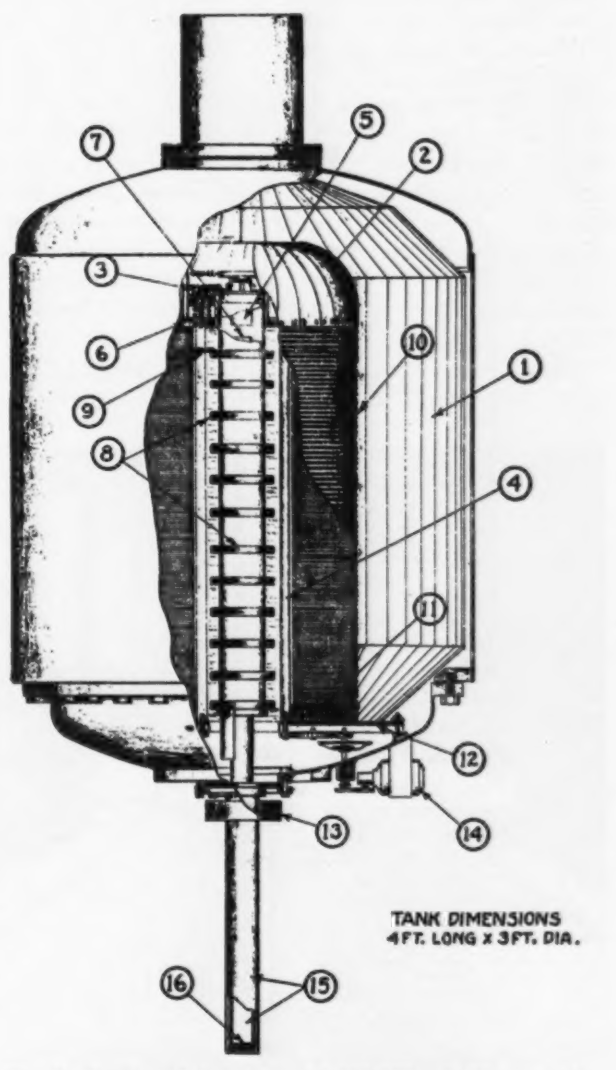

Fig. 2—Sectional drawing of 1,000,000-volt X-ray unit

(1) Laminated steel shell, (2) slotted brass shield, (3) variable reactor, (4) insulating filament-control shaft, (5) cathode assembly, (6) end-turn filament coil, (7) first intermediate electrode, (8) shields around the side, (9) tap lead, (10) secondary coils, (11) primary winding, (12) laminated steel bottom, (13) focusing coil, (14) filament control motor, (15) extension chamber with water-jacket, (16) target.

those obtained with the latter he attributed in large measure to the reduction in X-ray backscatter and to the use of a greater distance from X-ray source to film.

C. D. Moriarty described the X-Ray Laboratory at Schenectady and showed in detail the procedure involved in examining steel castings, such as turbine parts, valves, etc. The million-volt machine is housed in a room, the walls of which consist of 14 in. of concrete and 12 in. of brick. This wall protection extends 5 ft underground and the 1-in. steel door leading into the office is protected by an 18-in. concrete baffle. The trailer entrance door is of 2-in. steel plate and 18 in. of concrete. There is also a trap door in the roof for admission of large castings handled by an outside crane.

O. R. Carpenter of Babcock & Wilcox Company described the installation of a million-volt X-ray unit at the Barberton plant of his company, which, unlike the other units, is installed in a concrete pit along one wall and at one end of the welding shop; see Fig. 3. He compared X-raying at a million volts with the use of gamma rays, and pointed out that if it were possible to obtain and use 100 grams (about 3.2 ounces) of radium, worth about $2^1/_2$ million dollars, radiographs might be made as quickly as with the million-volt X-ray tube. The radium gives off gamma rays, which are similar to X-rays but of shorter wave length. However, though radium can be easily carried around and does not require the special electrical connections of the X-ray tube, the contrast of the resulting films, except in the thickest specimens of metal, is not so good as with X-rays. The relationship between gamma rays and various voltage X-ray equipment with respect to exposure times and various plate thicknesses is shown, Fig. 4. From this it will be noted that with 100 to 500 mg of radium the period falls into days in striking contrast with hours and minutes for X-rays.

"A further advantage of million-volt X-raying equipment," Mr. Carpenter said, "is that it no longer becomes

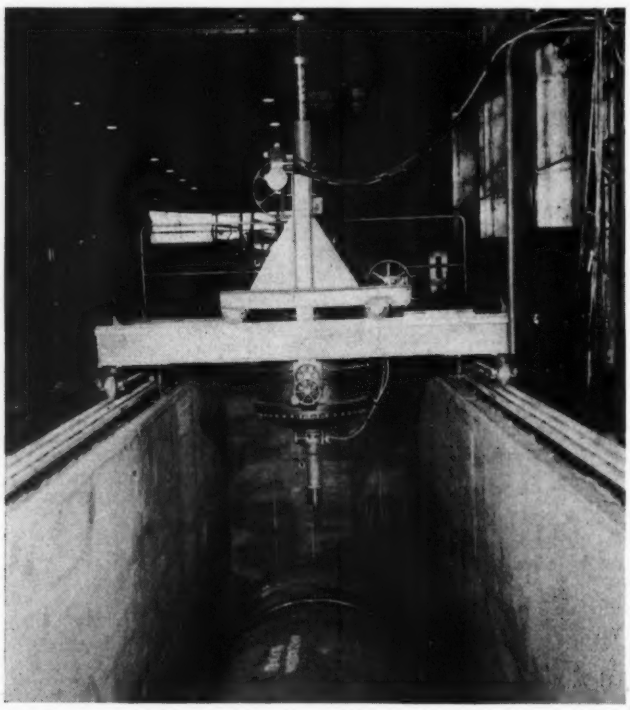

Fig. 3—The unit at Barberton is mounted over a pit in which the drum is placed

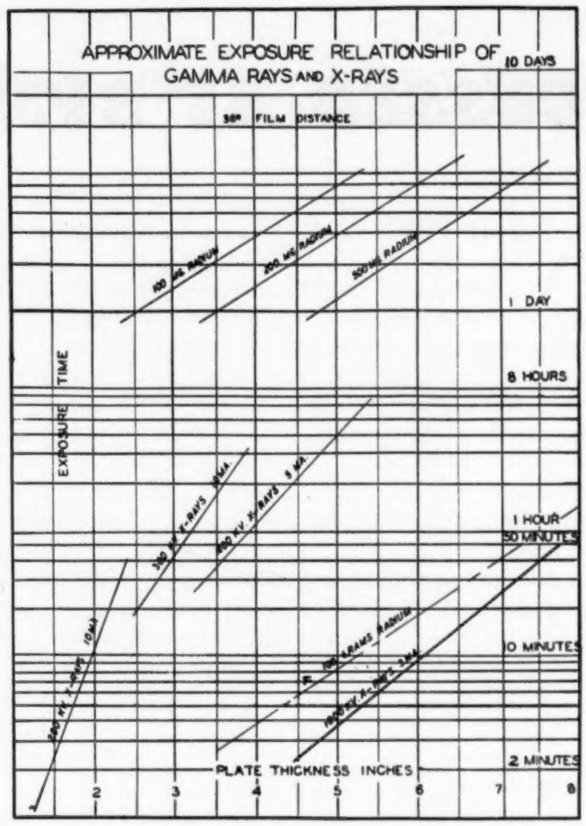

Fig. 4—Exposure relationship of gamma rays and X-rays

necessary to over-reach the penetration ranges of the lower-voltage equipment and each voltage may be applied to the particular thickness range with certain radiographic advantages."

A. J. Moses of Combustion Engineering reviewed the experience of his company over the past ten years in the radiographing of welded pressure vessels. Just prior to the acceptance by the A.S.M.E. Boiler Code of fusion welding of boiler drums and the X-ray as a reliable nondestructive means of testing, a two-tube, 200,000-volt air-cooled outfit had been purchased from the General Electric X-Ray Corporation. This proved satisfactory for the then prevailing weld thicknesses of $^1/_2$ to $2^1/_2$ in., but there was soon a demand for thicker plates and it became apparent that the 200,000-volt equipment had serious limitations as to sensitivity and reasonable exposure time in the heavier plate ranges. Practically all of the X-ray pictures of the heavier plates were showing up as perfect welds, which did not seem reasonable. The X-Ray Corporation was advised of this and a thorough joint investigation was undertaken which required many months.

In the meantime, on thicknesses over 2 in. the Company established the practice of double X-raying—once with the metal at an interstage thickness and again after the welding was completed, but this procedure was laborious and expensive.

At about that time the X-Ray Corporation brought out a 300,000-volt air-cooled industrial unit which was soon superseded by an oil-immersed unit, one of which was purchased by Combustion Engineering Company. While this machine permitted the X-raying of thicker plates, it demonstrated no improvement in sensitivity until the investigation that had been previously under-

taken resulted in the X-Ray Corporation bringing out an adaptation of the bucky grid. This made it possible to obtain reliable radiographs up to 4 in. thickness. However, the time of exposure with the grid on this thickness at 300,000 volts was excessive.

Next, the 400,000-volt oil-immersed outfit was developed and a machine purchased. This raised the limit of thickness to 5 in. for satisfactory radiographing and reasonable exposure time. With some later boiler drums of $5^1/_4$- to $5^3/_8$-in. plate thickness, the 400,000-volt machine and bucky required $7^1/_2$ hr to take individual pictures. Therefore, the development of the million-volt machine, which will take such pictures in 15 min, represents progress of the first magnitude.

Mr. Moses then briefly described the million-volt unit recently installed at the Chattanooga plant of Combustion Engineering Company which is housed in a separate building, 21 by 60 ft with 18-in. concrete walls carried to a sufficient height to insure protection to all personnel. The control equipment is located in an anteroom connected with the main room by a concrete maze and has additional lead protection. Power cannot be thrown on the X-ray tube until the doors are closed. The unit is assembled in a cradle, carried by an overhead crane, and can be traversed in three directions and rotated on trunnions from the vertical to the horizontal positions. This makes it possible to insert the tube through the manhole in the drum head and at one exposure take a picture of the whole circumferential seam. Thus a great saving is effected not only in the number of exposures but also in the setting-up time. Fig. 5 shows a large drum with the X-ray tube in position for radiographing a circumferential seam. Heretofore, this method of radiographing such seams has been possible only with the use of radium. Fig. 6 is a set-up for radiographing a longitudinal weld in a heavy drum. At present films 32 in. in length are being used in X-raying longitudinal seams.

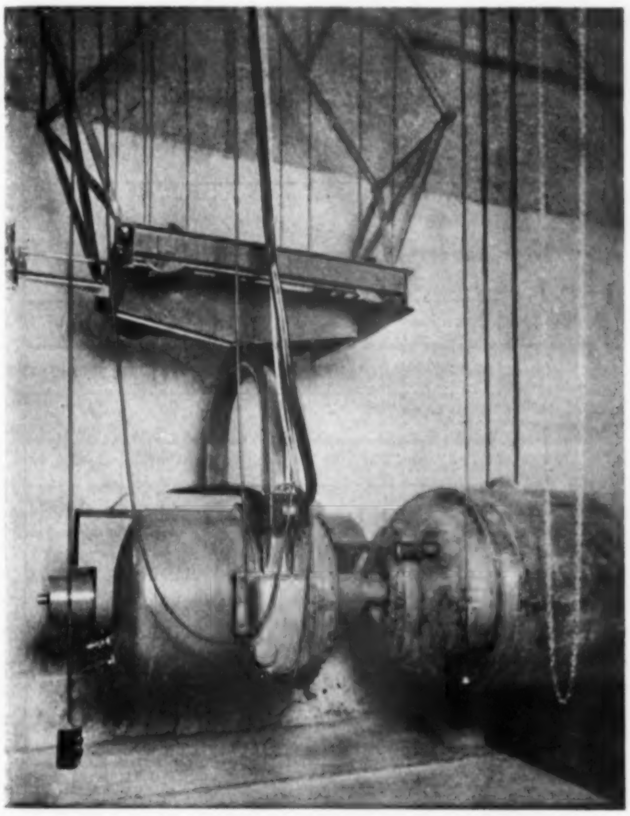

Fig. 5—The million-volt machine at Chattanooga in position to radiograph circumferential seam from inside of drum; note the flexible arrangement of the mounting

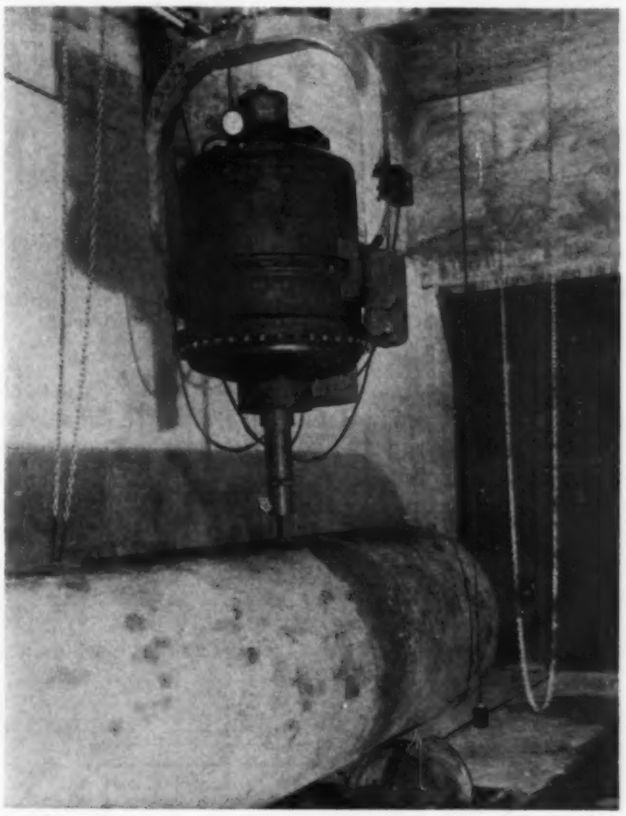

Fig. 6—Million-volt unit at Chattanooga in position to radiograph longitudinal weld

Fig. 7 represents exposure time for various plate thickness with 400,000 volts and with a million volts. It will be noted that the 400,000-volt performance is based on a 32-in. focal distance, whereas the million-volt performance is based on focal lengths of 32 to 60 in.

Fig. 8 shows a tabulation of the approximate technique for the million-volt industrial X-ray unit for thicknesses varying from $1^1/_8$ to 7 in. and for focal distances of 60, 48, 36 and 32 in. This is based on using a $^1/_4$-in. lead filter between the film and cassette and on single film viewing. While it is known that improvements can be made by using double films, full information has not yet been developed concerning this procedure.

From Fig. 9, which shows comparisons for equivalent focal distances with thicknesses ranging from 1 to $5^1/_4$ in., it will be noted that using a 32-in. focal distance for each machine, the time of exposure, in the case of $5^1/_4$-in. metal, with the million-volt machine is less than one per cent of that with the 400,000-volt machine.

Mr. Moses concluded with the observation that while there is little probability of much further improvement with the 400,000-volt machine and the bucky grid, there is likely to be room for much improvement in technique with the million-volt unit inasmuch as a study of its proper use and possibilities for X-raying pressure vessels was begun only a few weeks ago.

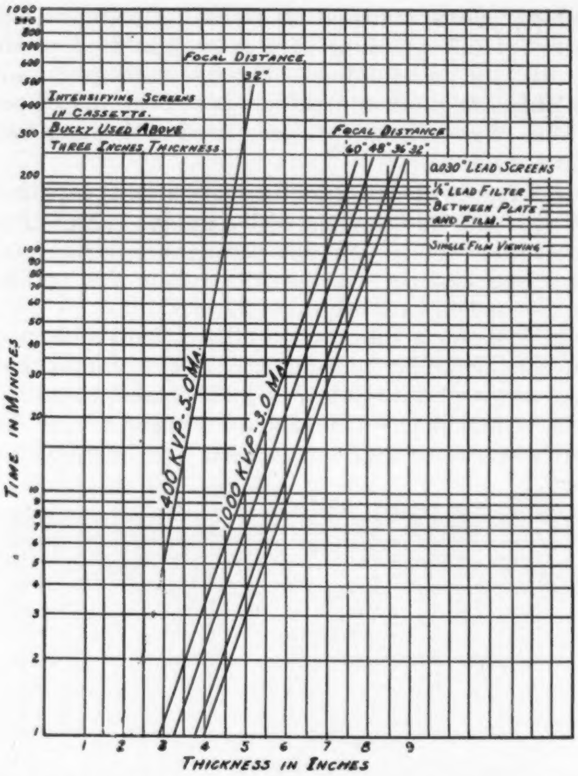

Fig. 7—Comparison of exposure time for different plate thicknesses with 400,000 volts and a million volts

E. W. Page of the General Electric X-Ray Corporation called attention to the fact that despite the advent of million-volt X-rays for industrial use, lower voltages, even as low as five or six thousand, continue to play an important part in many applications such as microradiographs, the examination of oranges, fats and proteins; and, in fact, many branches that lean heavily upon microscopic investigations.

In the line of defense equipment, the X-raying of navy turbines is an accepted routine and the welds and castings which go into high-pressure steam systems aboard ship must also be X-rayed. For the Army, the welds in gun carriages, as well as gun mounts, are subject to the scrutiny of the X-ray and certain parts of tanks and other heavy armament materials require radiographic examination. The rôle played by X-ray in the aircraft industry is equally important since many parts must be inspected 100 per cent; other parts which may be considered slightly less vital have a certain number of each lot so examined as a check on the standard of quality throughout the manufacturing process.

Since the parts mentioned range from comparatively thin aluminum to various thicknesses of copper and brass and heavy steels, different operating voltages are required. This has resulted in the design of several different types of X-ray equipment operating at voltages ranging from 60,000 to a million volts to fulfill the many requirements of this class of work.

For normal conditions of demand 60,000 to 140,000 volts would be satisfactory for the aluminum; 200,000 volts for $1^1/_2$-in. steel and 400,000 volts for thicker sections. However, with the defense program the element of time is vital and this has indicated the desirability of higher voltages to attain speed.

It was announced that four more million-volt X-ray units would be in operation shortly. One of these is being installed at the American Steel Foundries plant at Granite City, Ill.; a second at the Norfolk Navy Yard; a third at the Philadelphia Navy Yard; and the fourth at the Campbell, Wyant & Cannon Foundry Company at Muskegon, Mich., where it will be used to inspect armament and motor castings. The chief reason for the navy yard installations is to speed up radiographic inspection of heavy walled pressure vessels and to release a number of radium units for use in localities where X-ray service is not available.

Thickness	Kilovolt Peak	Milli-Amps	Time in Minutes			
			60" F.D.	48" F.D.	36" F.D.	32" F.D.
1 1/8"	890	0.5	1.00	—	—	—
1 1/2"	890	0.5	1.50	—	—	—
2 1/8"	950	1.5	1.50	1.00	—	—
2 1/2"	950	1.5	2.75	1.75	1.00	—
3 1/8"	950	1.5	5.00	3.20	1.80	1.25
3 1/2"	950	1.5	6.50	4.20	2.30	1.60
4 1/2"	1000	3.0	6.00	4.00	2.10	1.70
5"	1000	3.0	11.00	7.00	4.00	3.00
5 1/2"	1000	3.0	18.00	12.00	7.00	5.10
6"	1000	3.0	35.00	21.00	11.00	9.00
6 1/2"	1000	3.0	58.00	37.00	20.00	16.00
7"	1000	3.0	100.00	68.00	35.00	27.00

Fig. 8—Approximate technique for million-volt unit with $^1/_4$-in. lead filter between film and cassette; single film viewing

Thickness	Machine	K.V.P.	MA.	Focal Distance	Time Min.
1"	400 K.V.P.	170	5.0	42"	0.33
	1000 K.V.P.	890	0.5	42"	0.49
2"	400 K.V.P.	260	5.0	36"	1.25
	1000 K.V.P.	950	1.5	36"	0.54
3"	400 K.V.P.	367	5.0	32"	5.00
	1000 K.V.P.	950	1.5	32"	1.40
4"	400 K.V.P.	400	5.0	32"	35.00
	1000 K.V.P.	1000	3.0	32"	1.00
5"	400 K.V.P.	400	5.0	32"	270.00
	1000 K.V.P.	1000	3.0	32"	3.00
5 1/4"	400 K.V.P.	400	5.0	32"	450.00
	1000 K.V.P.	1000	3.0	32"	4.00

Fig. 9—Comparison of 400,000 and a million volts for equivalent focal distances with plate thickness ranging from 1 to $5^1/_4$ in.

Combustion Calculations by Graphical Methods—

COKE-OVEN GAS

This is the second article of a series, each dealing with a particular fuel, by which, through the use of charts, combustion calculations can be quickly and accurately made. The first article dealt with fuel oils, the present with coke-oven gas and the next will cover blast-furnace gas.

By A. L. NICOLAI,
Combustion Engineering Co., Inc.

COKE-OVEN gas, as the name implies, is a by-product in the manufacture of coke by the destructive distillation of bituminous coal. The raw coal is placed in ovens, which are externally heated until practically all the volatile matter is driven out. The coke-oven gas thus produced is made up chiefly of hydrogen, methane, ethylene and carbon monoxide with small percentages of carbon dioxide, nitrogen, oxygen and heavy hydrocarbons or illuminants. Table 2 lists the "saturated" and "unsaturated" or "illuminant" hydrocarbons that are most frequently found in gaseous fuels. Saturated hydrocarbons do not unite directly with hydrogen, i.e., they are stable in the presence of hydrogen, while unsaturated ones readily take on more hydrogen. The latter are also called illuminants because they burn with a bright luminous flame, as distinguished from the saturated hydrocarbons which produce a blue flame. The exact composition of coke-oven gas is influenced by the character of the raw coal and the length of time taken in the roasting operation, as may be seen in Fig. 1.[1]

As mentioned in the first article of this series,[2] gas manufacturers usually take 62 F and 30 in. Hg as standard conditions. The representative analyses given in Table 1 are reported in per cent by volume of gas saturated with moisture under these conditions.

As the coke-oven gas comes from the oven at high temperatures, it frequently contains various impurities in the form of tarry particles, dust, benzol and hydrogen sulphide. With rare exceptions, however, it is always washed and cooled before being sent to a storage tank and distributed for burning. It is, therefore, probable that the temperature under which actual combustion of this fuel occurs is close to 62 F, and that the coke-oven gas is nearly saturated with water vapor at this standard temperature.

Heating Value.—The high heating value of gaseous fuels is usually reported in Btu per cu ft. Due to a breaking down of the heavy hydrocarbons, carbonization at high temperatures generally results in calorific values varying from 400 to 600 Btu per cu ft; whereas low-temperature carbonization gives a smaller yield of coke-oven gas but a higher heating value, ranging from 600 to 1000 Btu per cu ft. Table 1 indicates a spread between 466 and 807 Btu per cu ft in the high heating value of the analyses selected. The heating value of a coke-oven gas, when not given, may be accurately determined by a summation of the heats evolved by the individual combustible constituents of the gas. It is the

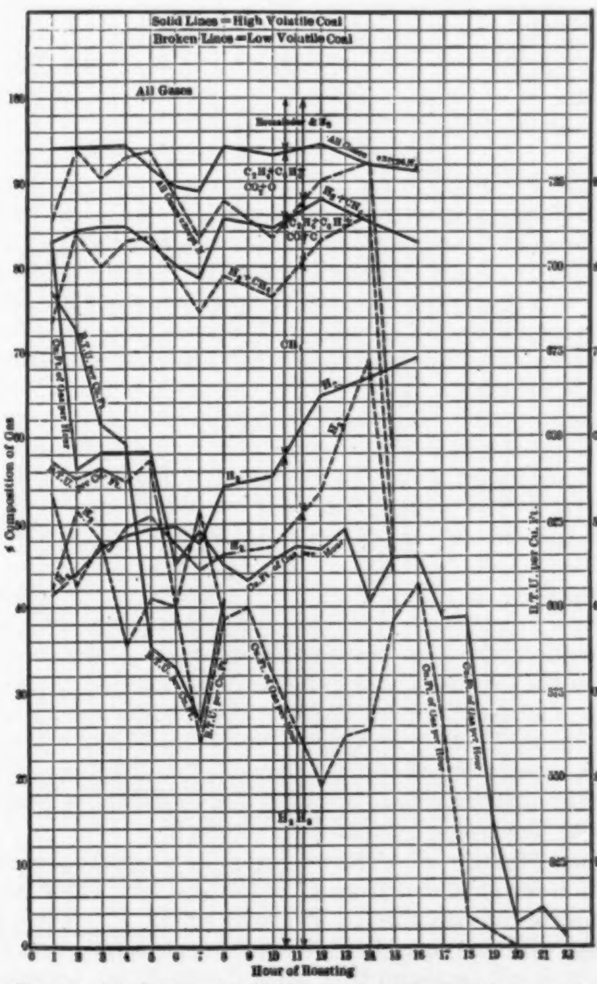

Fig. 1—Variation in the composition of by-product coke-oven gas with time of roasting

Reproduced from Lucke, *Engineering Thermodynamics*, by permission of Columbia University Press

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[1] Engineering Thermodynamics, by C. E. Lucke.
[2] COMBUSTION, August 1941.

sum of the products of each combustible constituent and its corresponding heating value as read from Table 2.

It is important to have the correct calorific value at 62 F and 30 in. Hg for a given analysis, since the method employed by the writer relates all combustion calculations to the heat liberated. Unfortunately, many analyses show the heavier hydrocarbons grouped together as "illuminants." DeBaufre[3] and others have suggested taking the illuminants to be propylene, C_3H_6. While this assumption is valid in calculating the Btu per cu ft, it will not give accurate values of H_2O formed by combustion, and the resulting heat balance will be in error. A complete gas analysis, including all hydrocarbons, is, therefore, essential for accurate work. If, for any reason, it is required to find the high heating value in Btu per lb accurately, the simplest way is to divide the Btu per cu ft by the fuel density.

Density.—The density of the gaseous fuel, in turn, may be obtained by adding together the weights of the constituents in the fuel. The following tabulation is an example of density calculation for the typical coke-oven gas listed first in Table 1, the density of the individual constituents being taken from Table 2.

	Per Cent by Volume	Volume, Cu Ft per Cu Ft	Density of Constituent, Lb per Cu Ft	Weight, Lb per Cu Ft
Carbon dioxide, CO_2	1.8	0.018	× 0.1147	= 0.00207
Oxygen, O_2	0.2	0.002	× 0.0836	= 0.00017
Nitrogen, N_2	3.4	0.034	× 0.0737	= 0.00251
Carbon monoxide, CO	6.3	0.063	× 0.0733	= 0.00462
Hydrogen, H_2	53.0	0.530	× 0.00604	= 0.00320
Methane, CH_4	31.6	0.316	× 0.0423	= 0.01339
Ethylene, C_2H_4	2.7	0.027	× 0.0733	= 0.00198
Benzol, C_6H_6	1.0	0.010	× 0.2027	= 0.00203
Total				0.02997*

* Lb per cu ft density of coke-oven gas, saturated with moisture.

Fuel, F.—Fig. 1 of the first article[2] shows how to determine F, that portion of the fuel which reappears in volatile form in the products of combustion, when HHV, the Btu per lb of fuel, is known. But the Btu per lb is seldom determined or reported for a gaseous fuel. However, for purposes of calculating F, a mean value of 17,990 Btu per lb may be assumed which, with zero combustible loss, corresponds to F = 57 lb per million Btu. This arbitrary value of F does not appreciably change the error in the weight of the products of combustion caused by inaccuracies in the volumetric determination of the analysis. The assumption of F = 57 lb does away with the necessity of converting the Btu per cu ft to Btu per lb.

Atmospheric Air, A.—Fig. 2 of the present article offers a simple method for obtaining the atmospheric air. Generally, with an increase of the hydrogen in the analysis, at the expense of the hydrocarbons, values of A read from Curve A will be found to be slightly low, and, vice versa, a larger proportion of hydrocarbons will require more atmospheric air than is given by Curve A. Barring extreme cases, however, the variation is small, as may be verified by examining Table 1.

Total Products, P.—The weight of the products of combustion is calculated from $P = F + CA$.[2] Therefore, any error in either A or F shows up in P. With F always assumed equal to 57 lb, and A read from Curve A, Fig. 2, it will be found that when the deviation between the curve reading and actual calculation of A is positive, the deviation in F is negative, so that any error in A compensates, rather than adds to, any error in F.

Moisture from Fuel, W_f.—The moisture, W_c, in a fuel gas saturated at 62 F may well be neglected as it amounts to less than 2 lb per million Btu as fired. W_h, the water formed by the combustion of hydrogen and the hydrocarbons present in the coke-oven gas, is obtained from Curves B, Fig. 2. Since W_c is neglected, W_f which is the total moisture in the flue gases derived from the fuel is equal to W_h.

In the simple case of hydrogen, the volumetric chemical equation for combustion is

$$H_2 + {}^1/_2O_2 = H_2O \qquad (8)$$

Equation (8) shows that one volume of hydrogen combines with one-half volume of oxygen to produce one volume of water. Similarly, one volume of CH_4 will form, on burning, two volumes of H_2O, etc. Since a coke-oven gas may contain H_2, CH_4, C_2H_4, C_6H_6, with the aid of Table 2, it is seen that the total volume of H_2O evolved by these constituents is equal to ($H_2 + 2CH_4 + 2C_2H_4 + 3C_6H_6$). The conversion of the volume of H_2O to pound per million Btu is accomplished by using the following exact relation:

$$W_h = 46{,}700\,\frac{(H_2 + 2CH_4 + 2C_2H_4 + 3C_6H_6)}{\text{Btu per cu ft at 62 F and 30 in. Hg}} \qquad (9)$$

which is also plotted as Curves B, Fig. 2.

Since equations similar to (9) will be used in discussing other gaseous fuels in the future, it may not be amiss to state the following simple rule: *Each constituent in the fuel will form a volume of water equal to $^1/_2$ of its hydrogen atoms.*

Per Cent CO_2 in Products.—There are many constituents in coke-oven gas which on burning will evolve CO_2. A simple equation relating exactly the CO_2 in the dry products of combustion to these constituents cannot be written, but the following equation will be found sufficiently accurate for analyses which do not contain excessive amounts of N_2 or O_2.

Per cent CO_2 (at zero excess air) =

$$\frac{1}{1 + \dfrac{713 \times \text{Btu per cu ft at 62 F and 30 in. Hg}}{(100 + C_2H_4 + 5C_6H_6) - (H_2 + N_2)}} \qquad (10)$$

Curves C, Fig. 2, are nothing more than a plot of equation (10), while Curves D serve as guide lines for determining the per cent CO_2 in the dry products of combustion for any other value of excess air than zero.

The tables and typical example have been placed on the reverse side of the chart (see page 42) so as to provide a convenient arrangement should the reader desire to clip and file the chart without including the whole article. A similar arrangement will be provided with the subsequent charts covering natural gas, blast-furnace gas, bagasse, wood and other fuels—EDITOR.

[3] COMBUSTION, December 1931.

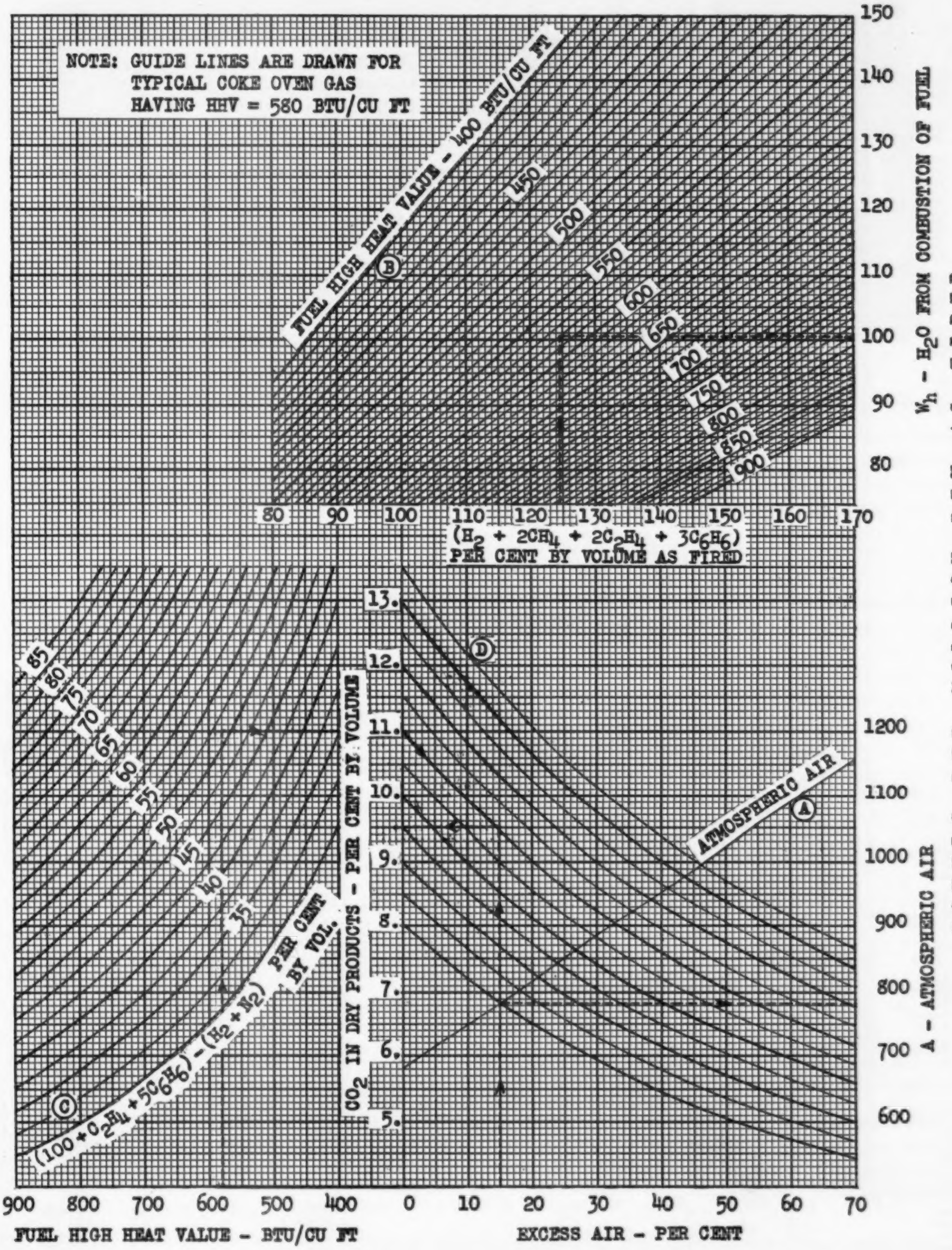


Fig. 2—Chart for coke-oven gas

Coke-Oven Gas

(See chart on reverse page)

Example

Assume a coke-oven gas with the typical analysis listed first in Table 1 to be burned with 15 per cent excess air. Then,

1. *Fuel, F.* For value of F, see preceding description of calculation. As pointed out, the error in the products of combustion is negligible in assuming $F = 57$ lb per million Btu.

2. *Atmospheric Air, A.* From Curve A, Fig. 2, read $A = 782$ lb per million Btu.

3. *Unburned Combustible.* For stationary boiler furnaces, the general assumption when burning coke-oven gas is that there is no combustible heat loss. Therefore, C in equations (3) and (4)[2] is equal to 1.

4. *Total Products, P.* From equation (4),[2] $P = F + CA = 57 + 782 \times 1 = 839$ lb per million Btu.

5. *Moisture in Air, W_a.* From equation (5),[2] $W_a = 0.013A = 0.013 \times 782 = 10$ lb per million Btu.

6. *Moisture from Fuel, W_f.* Since $W_c = 0$, from Curves B, Fig. 2, for a high heating value of 580 Btu per cu ft and $H_2 + 2CH_4 + 2C_2H_4 + 3C_6H_6 = 53.0 + 63.2 + 5.4 + 3.0 = 124.6$ per cent by volume, read $W_f = W_h = 100.5$ lb per million Btu.

7. *Dry Gas, P_d.* From equation (7),[2] $P_d = P - (W_a + W_f) = 839 - (10 + 100.5) = 728$ lb per million Btu.

8. *Per cent CO_2 in Products.* For a heating value of 580 Btu per cu ft and $(100 + C_2H_4 + 5C_6H_6) - (H_2 + N_2) = (100 + 2.7 + 5.0) - (53.0 + 3.4) = 51.3$ per cent by volume, from Curves C, Fig. 2 read 11.0 per cent CO_2 at zero excess air. Following Curves D as guide lines to 15 per cent excess air, read $CO_2 = 9.5$ per cent.

TABLE 1—CHARACTERISTICS OF TYPICAL COKE-OVEN GASES

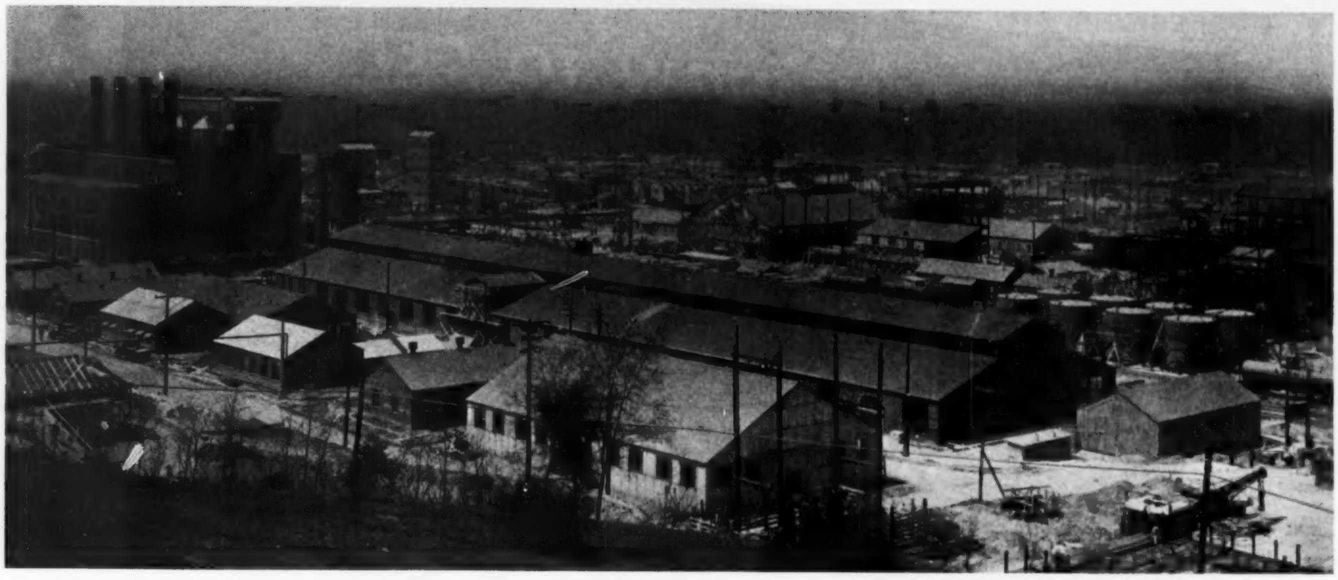
%CO_2	%O_2	%N_2	%CO	%H_2	%CH_4	%C_2H_4	%C_6H_6	Density Lb per Cu Ft	Heat Value Btu per Cu Ft High	Heat Value Btu per Cu Ft Low	Heat Value Btu per Lb High	Heat Value Btu per Lb Low	Atmos. Air at Zero Excess Air Lb per 10^6 Btu	CO_2 at Zero Excess Air, %
1.8	0.2	3.4	6.3	53.0	31.6	2.7	1.0	0.0300	580	519	19,320	17,310	678	11.0
1.4	0.5	4.2	5.1	57.4	28.5	2.9	..	0.0265	526	468	19,820	17,680	666	10.0
2.6	0.6	3.7	6.1	47.9	33.9	5.2	..	0.0318	588	527	18,500	16,590	677	11.3
3.13	...	..	11.93	42.16	37.14	4.76	0.88	0.0359	645	583	17,970	16,250	687	12.7
0.1	...	2.4	6.8	27.7	50.0	13.0	..	0.0393	807	731	20,550	18,600	702	12.3
1.50	...	12.1	6.0	53.0	28.15	..	..	0.0302	466	414	15,420	13,720	667	9.5

TABLE 2—SIMPLE GASES SATURATED WITH MOISTURE AT 62 F AND 30 IN. Hg

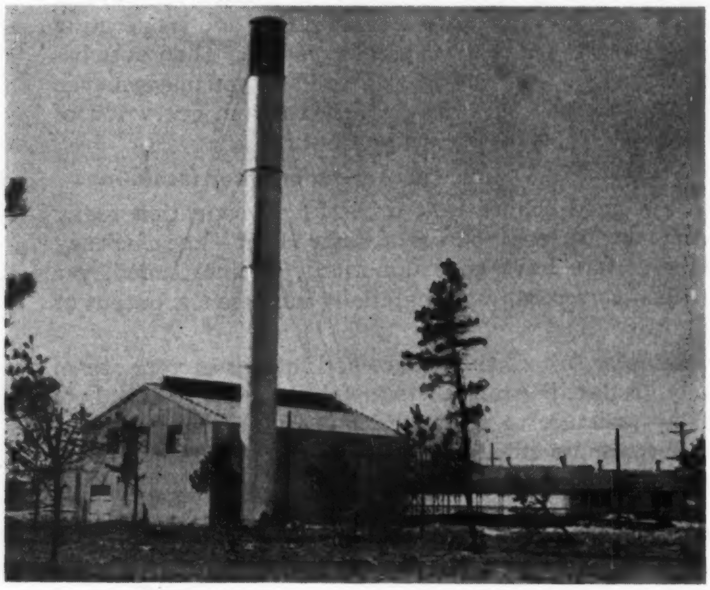
Gas	Chemical Formula	O_2 Reqd. per Cu Ft of Dry Gas, Cu Ft	CO_2 Formed per Cu Ft of Dry Gas, Cu Ft	H_2O Formed per Cu Ft of Dry Gas, Cu Ft	Density of Sat. Gas, Lb per Cu Ft	Heating Value of Saturated Gas Btu per Cu Ft High	Heating Value of Saturated Gas Btu per Cu Ft Low	Heating Value of Saturated Gas Btu per Lb High	Heating Value of Saturated Gas Btu per Lb Low
Oxygen	O_2	−1.0	...	...	0.08361	....	....	....	....
Nitrogen	N_2	...	...	...	0.07372	....	....	....	....
Air	...	...	...	...	0.07578	....	....	....	....
Carbon dioxide	CO_2	...	1.0	...	0.11465	....	....	....	....
Water vapor	H_2O	...	...	1.0	0.04743	....	....	....	....
Hydrogen	H_2	0.5	...	1.0	0.00604	318.3	269.4	52,720	44,620
Hydrogen sulphide	H_2S	1.5	1.0*	1.0	0.08898	616.6	567.7	6,930	6,380
Carbon monoxide	CO	0.5	1.0	...	0.07326	314.8	314.8	4,300	4,300
Saturated Hydrocarbons:									
Methane	CH_4	2.0	1.0	2.0	0.04230	991	894	23,440	21,130
Ethane	C_2H_6	3.5	2.0	3.0	0.07855	1715	1569	21,840	19,970
Propane	C_3H_8	5.0	3.0	4.0	0.11481	2451	2255	21,340	19,640
Butane	C_4H_{10}	6.5	4.0	5.0	0.15106	3182	2938	21,060	19,450
Pentane	C_5H_{12}	8.0	5.0	6.0	0.18731	3903	3609	20,840	19,270
Unsaturated Hydrocarbons or Illuminants:									
Ethylene	C_2H_4	3.0	2.0	2.0	0.07334	1546	1448	21,080	19,750
Propylene	C_3H_6	4.5	3.0	3.0	0.10959	2313	2167	21,110	19,770
Butylene	C_4H_8	6.0	4.0	4.0	0.14585	3013	2818	20,660	19,320
Pentylene	C_5H_{10}	7.5	5.0	5.0	0.18210	3742	3498	20,550	19,210
Acetylene	C_2H_2	2.5	2.0	1.0	0.06812	1452	1404	21,320	20,610
Benzol	C_6H_6	7.5	6.0	3.0	0.20271	3666	3520	18,080	17,360
Toluol	C_7H_8	9.0	7.0	4.0	0.23897	4358	4163	18,240	17,420

* SO_2.

SOME POWER PLANTS



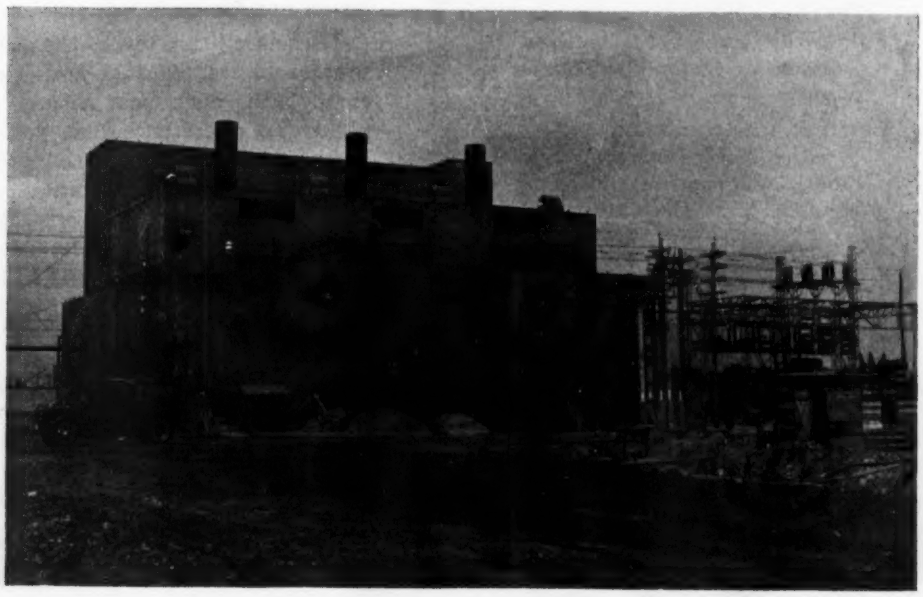
Radford Ordnance Works, Radford, Va., containing four 175,000-lb per hr steam generating units



A typical hospital boiler plant at one of the camps

MUCH publicity has been given to the cooperative plans being carried out between the Federal Power Commission and the electric utilities with the object of providing ample public supply of electricity for the defense program. These involve construction of new stations and additions to existing plants.

For obvious reasons, little has been published concerning the extensive power facilities provided for the numerous munitions plants and operating bases constructed by or under the direction of the military branches of the Government. These include plants for the production of explosives, loading plants, extensions to existing manufacturing arsenals and navy yards, air bases and troop training centers. Some of these establishments will be privately operated under military supervision whereas others come under direct operation by the Government.



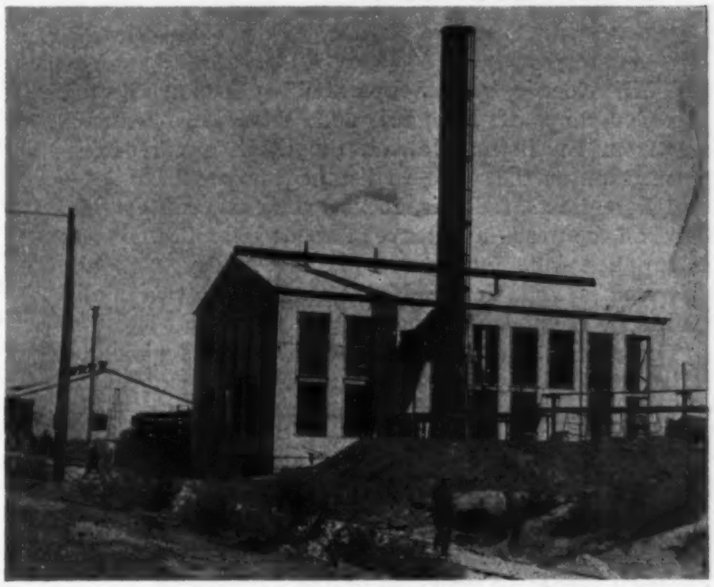
Power plant of Kankakee Ordnance Works, Elwood, Ill., containing six 125,000-lb per hr steam generating units

SERVING DEFENSE ACTIVITIES

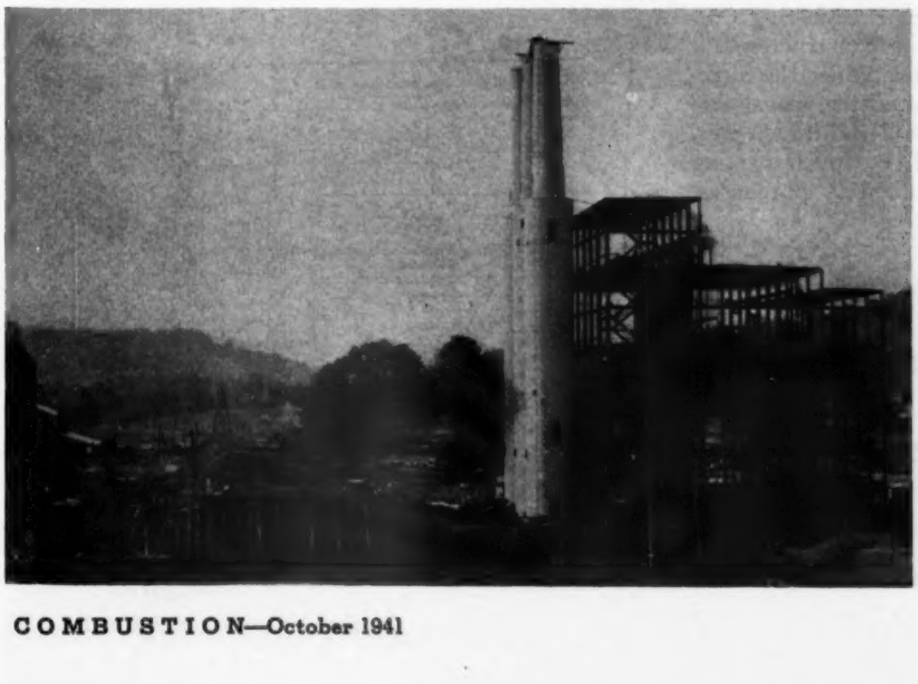
Indiana Ordnance Plant, Charleston, Ind., Power plant laid out for eleven 160,000-lb per hr boilers

In many cases the nature of the manufacturing process involves large steam demands and this dictated the construction of individual power plants rather than the use of public power supply. Although the total number of such plants is not readily ascertainable, an idea of their magnitude can be gained from the fact that a checkup on fifty accounts for a total installed steam generating capacity of nearly 8 million pounds per hour. Many of these establishments cover vast areas and the power plants serving them are essentially central stations; the largest has eleven boilers, each of 160,000-lb per hr capacity; and several others range from 400,000 to 800,000-lb total capacity. Among the larger plants 450 to 600-lb steam pressure is common.

Through the courtesy of the War Department we are privileged to present pictures of a few of these representative installations.



Boiler house of Kingsbury Ordnance Plant, now nearing completion



Stacks and boilers under erection at Morgantown Ordnance Works, Morgantown, W. Va.

VENICE PLANT NO. 2 of Union Electric Co. of Illinois

By R. R. Wisner* and Stanley Stokes†

These excerpts from a paper before A.I.E.E. at St. Louis, Oct. 9, deal with mechanical features of the first two sections of this new plant, aggregating 160,000 kw. The plant is laid out on the unit principle and the ultimate capacity, as planned, will be 400,000 kw. Steam conditions are 850-lb pressure, 900 F total steam temperature and condensing operation. The paper also dealt in detail with the electrical features of the plant which are not here included.

THE electric system operated by Union Electric Company of Missouri and subsidiaries extends from Burlington, Ia., on the north to Fredericktown, Mo., on the south—a distance of some 220 miles—and from East St. Louis, Ill., on the east, to Lakeside, Mo., on the west—a distance of about 150 miles. Power is supplied from four steam plants: Ashley, Cahokia, Rivermines and Venice No. 1, and from two hydro plants: Keokuk and Osage.

The service area includes the St. Louis region and adjacent territory, an area around Keokuk, and a smaller area surrounding Lakeside, Mo. In the larger of the urban communities, there is a wide diversity of industries. A careful analysis of the system load made in 1939 indicated the necessity for additional system capacity in 1941. Engineering studies which had been under way for several years had demonstrated that the capacity should be provided at the Venice site.

Dr. Wm. McClellan, President of Union Electric Company, engaged Stone & Webster Engineering Corporation to design and supervise the construction for the Union Electric Company of Illinois under the direction of the company's Design Committee, consisting of E. T. Gushee, H. E. Kleffel, G. K. Miltenberger, Stanley Stokes and E. H. Tenney; M. B. Covell meeting with the Committee on matters related to purchases, negotiation of contracts and expediting.

The Venice plant site is on the east bank of the Mississippi River directly opposite St. Louis, about three miles north of the downtown district. Adequate railroad facilities exist adjacent to this site, and the Mississippi provides an adequate source of condensing water. A small steam plant of 62,500-kw capacity, Venice No. 1, has been in existence on the site for some years with water intake facilities sufficient for a much larger plant.

Plans for the site required relocation and reconstruction of the levee for a distance of approximately 1000 ft. There is a rise of about 53 ft from recorded low water to predicted high water. The original ground level behind the levee was about 20 ft below the top of the levee, but the yard is being filled so that this will be reduced to 11 ft.

The initial section of the new station includes structures to house two 40,000-kw turbine-generators, and two 360,000-lb per hr boilers, with electrical bay, office bay, machine shop and locker room, warehouse, transformer repair house, blacksmith shop, car dumper house, coal breaker house, track scale, outdoor substation, transmission towers, levee construction and railroad trackwork. While work was under way on this construction, a second section of the plant was authorized and started, consisting of structures to house an 80,000-kw turbine-generator and two 375,000-lb per hr boilers. Fig. 1 shows the general arrangement.

By reference to the cross-section (Fig. 2) it will be noted that the arrangement of boiler room, turbine room and electrical bay is the reverse of the more usual arrangement in which the turbine room and electrical bay are nearest the water. This grouping was governed by two principal considerations. The first was the desire to avoid the deep excavation for the condenser room close to the levee; the second was the fact that while considerable power is sent directly across the river, the major part of the new capacity serves the transmission

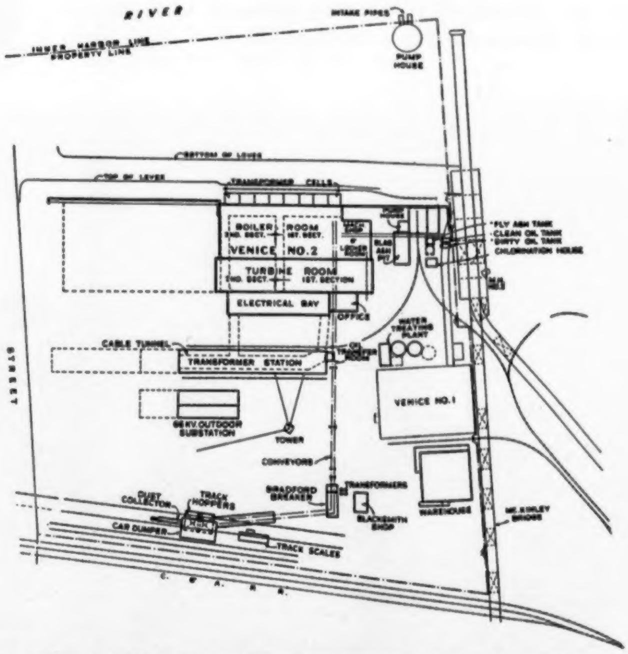


Fig. 1—Plan showing arrangement of station site

* Assistant Chief Electrical Engineer, Stone & Webster Engineering Corporation.
† Chief Electrical Engineer, Union Electric Company of Missouri.

system in all directions, requiring a large outdoor substation which it was advisable to locate on the land side of the plant. This made it desirable to place the turbine room and electrical bay on the land side also. Distribution across the river to St. Louis is provided by transformers on the levee adjacent to the station wall, connected with the electrical bay by cable tunnels running under the turbine-room operating floor and through the basement under the boiler-room ash floor.

Mechanical Design

The station is designed on the unit basis, and is fundamentally conceived as consisting of 80,000-kw units, of which the first is split into two 40,000-kw sections for operating convenience. Each 40,000-kw section is a complete power plant, with boiler, heaters, feed pumps and all auxiliaries. The 80,000-kw unit will have two boilers due to the limitations of dry-bottom operation with the available coal, but the two boilers will be operated as a unit, and pumps, heaters and all other auxiliaries are on a strictly unit basis.

Steam is supplied to the turbine throttles at 850 lb per sq in. and 900 F. The selection of these steam conditions was the result of balancing capital costs, which are high at the present time, against fuel costs, which are comparatively low in this part of Illinois.

Boilers for the first section were supplied by Combustion Engineering Company, Inc. Each has three pulverizers, two burners being supplied by each of the mills. The six burners are all located in the front furnace wall, and are of the horizontal turbulent type. One of the three mills and its pair of burners is designed for light-load operation. Combustion air is preheated in Ljungstrom preheaters, and draft is supplied by combination forced- and induced-draft fans, of which there are two for each boiler. The fans are driven by constant-speed motors through hydraulic couplings.

The second section boilers will be supplied by Riley Stoker Corporation. Each will have three pulverizers and six burners of equal capacity. These boilers will have tubular air preheaters, but otherwise the boiler auxiliaries will be of the same type as those in the first section.

Coal is delivered from cars to a track hopper, conveyed to the Bradford breaker, and then on a long inclined conveyor to the bunkers. Every effort has been made to avoid dust nuisance in handling coal. The car dumper is totally enclosed, and a suction system removes dust from this building, and also from the breaker house and each transfer point in the coal handling system. The bunkers are sealed at the trippers, and all dust collected is returned to the bunkers.

Cottrell precipitators are provided for each boiler. Dust from the precipitators is delivered to a silo north of the station by a suction conveyor, while a sluicing system conveys the ash from the furnace bottoms to a sump.

A complete system of instrumentation and control has been provided for all mechanical equipment. From boards located in the turbine-room basement, operators observe and control all details of the circulating water and feedwater systems. From the boiler-room operating boards, adjacent to the coal feeders, the operators observe all details of the feedwater system and combustion apparatus, the latter being normally under automatic control. From the same boards, the operators can control combustion manually, and can take over the control of the feedwater supply system in an emergency.

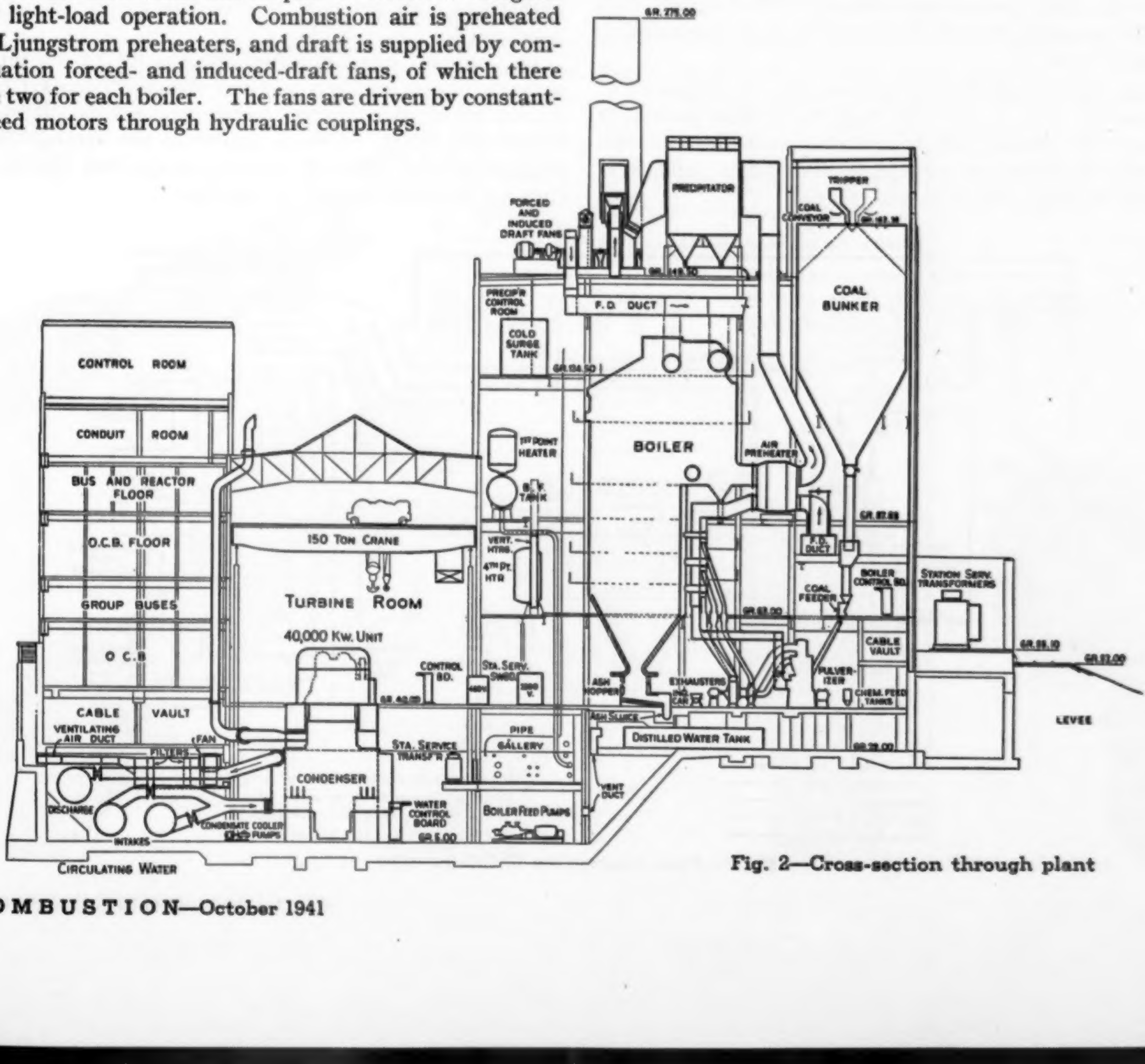


Fig. 2—Cross-section through plant

The first two 40,000-kw turbine-generator units supplied by Allis-Chalmers Manufacturing Company will be controlled by either of two independent operating governors, both of which will be of the relay or actuator type. One will be a standard relay-type speed-responsive governor with a fixed regulation of about 4 per cent, and will have an adjustable load limit. The other will be a so-called "super-sensitive" speed-responsive governor with adjustable regulation, speed-drop compensation, load and load-limit indication and adjustment. The latter is designed for a sensitivity of $^1/_{100}$ of 1 per cent, and is being supplied by the Woodward Governor Company. Either governor can control the unit through a common regulating valve and hydraulic cylinder. In addition, the change from one governor to the other, or from one adjustment to another, can be easily made while the units are in operation. This arrangement will provide considerable latitude in selecting the governor characteristics best suited to operating conditions on the system at any particular time. The governor system will be equipped so that the units may be synchronized from the switchboard room at any system speed from 5 per cent above to 10 per cent below normal.

A nominal generating voltage of 13.8 kv is the system standard and there would be no economy in using any other generating voltage because no energy is to be distributed from this station at a voltage lower than 33 kv, and this is higher than the maximum generator voltage practically obtainable at this time.

The maximum ultimate development on this site was established as 400,000 kw. The first two generators are 40,000 kw each, the third generator is 80,000, and future machines may consist of three 80,000-kw units, four 50,000-kw units, five 40,000-kw units or a combination of these sizes.

With the completion of the present development at Venice No. 2, it is expected that the system reserve of at least 125,000 kw will be maintained. This provides for the simultaneous outage of the largest and next largest generator units on the system.

The two 40,000-kw units for the first section, supplied by Allis-Chalmers Manufacturing Company, have air-cooled generators, but the generator for the 80,000-kw turbine in the second section, supplied by General Electric Company, will be hydrogen-cooled.

Auxiliary Supply

Heat-balance studies dictated the use of motor-driven auxiliaries. The unit system of supply was selected and to accomplish this, the power source for all auxiliaries directly associated with each generator and boiler unit is taken from the corresponding generator group bus. Auxiliary supply systems of 2300 volts and 440 volts are provided because some of the motors are more suitable for operation at the higher voltage while others are best suited for the lower voltage. The division between the motors for these two voltages, because of many factors, could not be made on a definite line of demarcation such as a certain horsepower capacity or essential and non-essential auxiliaries.

The power required for the auxiliaries installed in the first 80,000-kw section is relatively large because of the items common to the second and future sections, such as the circulating water pumping and coal handling and preparation facilities.

The 2300-volt bus system for the first plant section consists of a ring bus sectionalized on the basis of two main unit buses and one common bus. This ring bus is not intended to operate normally closed. Each unit bus is connected through 15,000 kva of transformer capacity to its associated 13.8-kv generator group bus, giving a total of 30,000 kva supplying this bus system. Since the total corresponding station auxiliary load is 15,000 kva, 100 per cent reserve transformer capacity is provided.

The 440-volt bus system for the two 40,000-kw units consists of two unit bus sections and one common bus section which is connected between the adjacent ends of the unit buses. This is similar to the arrangement adopted for the 2300-volt system, except that the outer ends are not tied through a ring bus.

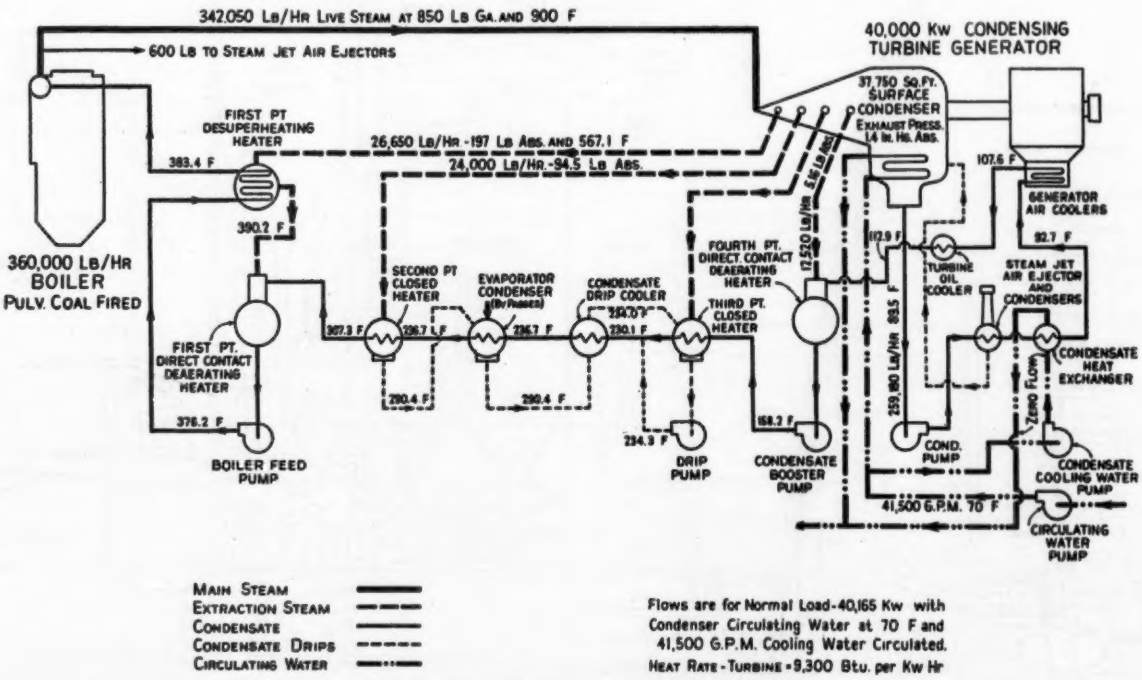


Fig. 3—Flow diagram for 40,000-kw unit

In the army it's guns, *In the boiler room it's*

LAGONDA-LIBERTY

TUBE CLEANERS

Our Army needs all sizes of guns for defense. 155 M.M. for laying down large-range barrages; 75 M.M. guns for anti-tank and anti-aircraft defense; 30 calibre rifles and 45 calibre pistols for individual short range firing. In the same way, boiler rooms need all sizes of cleaners for different tubes.

Like guns for defense, Lagonda-Liberty Tube Cleaners come in all sizes and types and for many purposes. There is a cleaner for every heat exchanger, condenser or boiler tube.

In these days of increased power — and consequent increased boiler scale — good, fast tube cleaners are a requisite. Lagonda-Liberty cleaners have the stuff to do a quick and thorough job on all tubes from ½" I.D. upwards, on tubes straight or curved.

There are forty years of tube cleaning experience back of every Lagonda-Liberty cleaner. Protect your boiler room efficiency — maintain defense schedules by using these modern cleaners. *Write for details.*

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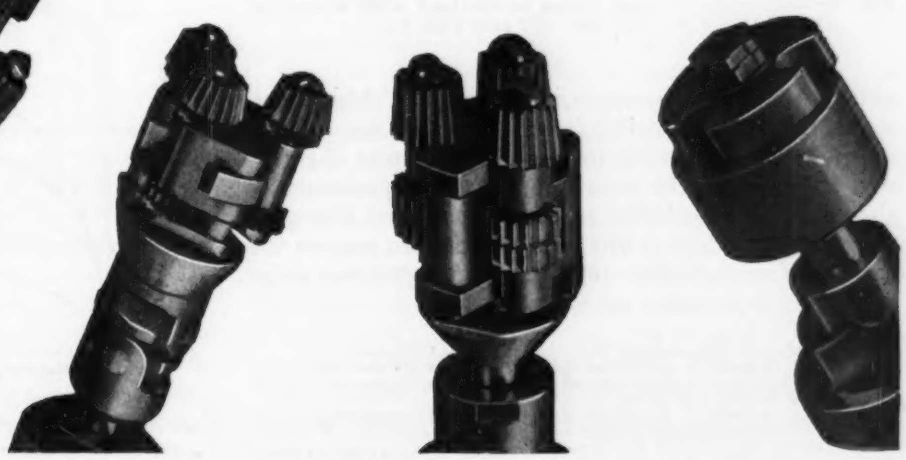

Corrosion of Steel by Steam at High Temperature

Inasmuch as steam temperatures in modern central stations are approaching those used for the commercial production of hydrogen by the reaction between steam and iron, an investigation was undertaken by Purdue University of the corrosion by steam of the various steels available for high-temperature steam service. Oxidation due to temperatures up to 1200 F and to pressures up to at least 1600 lb per sq in. was measured. The results were reported in a paper by Messrs. H. L. Solberg,[1] G. A. Hawkins[2] and A. A. Potter,[3] at the Fall Meeting of the A.S.M.E. at Louisville, Ky., October 12 to 15, 1941. The following abstract presents some of the high spots.

A PREVIOUS progress report[4] presented by the authors before the A.S.M.E. in 1937 showed the effect of temperatures from 800 to 1200 F on the oxidation of low-carbon steel in contact with steam at 1200 lb per sq in. in which it was found that the rate of oxidation of low-carbon steel at 1100 F is independent of pressure between 400 and 1200 lb, the range explored.

The present report deals with a continuation of the investigation with unstressed specimens of a wide variety of steels and alloys having for its object the effect of various types of surface finish and methods of scale removal; the effect of time of exposure to steam at 1100 F for various intervals of time up to 2000 hr; the effect of exposure for 500 hr at steady steam temperatures from 1000 F to 1300 F; the effect of temperature fluctuations on the corrosion resistance and spalling of scale on round bars as well as convex, concave and flat surfaces; and the corrosion of cast steels and special alloys.

Methods Used for Measuring Corrosion Products

Steam reacts with steel according to the equation

$$4H_2O + 3Fe = Fe_3O_4 + 4H_2$$

While this reaction indicates that the amount of corrosion could be measured from the quantity of hydrogen evolved, the occluded gases in the steel and the permeability of steel to hydrogen introduced variables which made the method unsuited for this investigation.

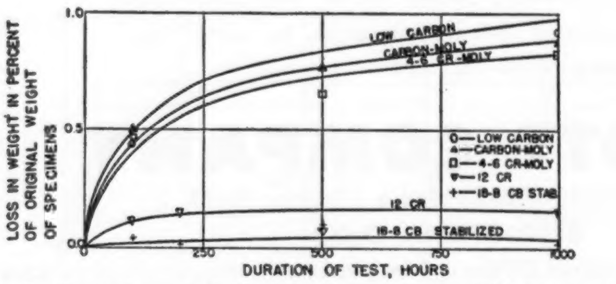

Fig. 1—Corrosion of steel tubes in contact with steam at 1100 F for 100, 200, 500 and 1000 hr.

An attempt was made to measure the extent of corrosion by stripping the scale from corroded specimens by the use of hydrochloric acid, antimony trioxide and stannous chloride, but this solution failed to remove the scale from steels high in chromium, although it was satisfactory for low-carbon steel.

A series of experiments with other acid and inhibitor combinations was then undertaken and it was found that a 34 per cent sulphuric acid solution with 0.1 per cent quinoline ethiodide would remove the scale from low-alloy steels with no appreciable attack on the base metal. However, no combinations of acids or concentrations of quinoline ethiodide would remove the scale from steels containing 12 per cent chromium or more without pitting the metal.

Scale removal by electrolysis was also tried, but the method finally adopted consisted of weighing the clean specimen before exposure to steam, removing the scale by electrolytic stripping after exposure to high-temperature steam, and reweighing the specimen. The solution consisted of 10 per cent sulphuric acid with one gram per liter of quinoline ethiodide, the specimen serving as the cathode. The time required for stripping with a current density of one ampere per square inch varied with the chromium content.

All the specimens were annealed, the cast steels being received in an annealed condition.

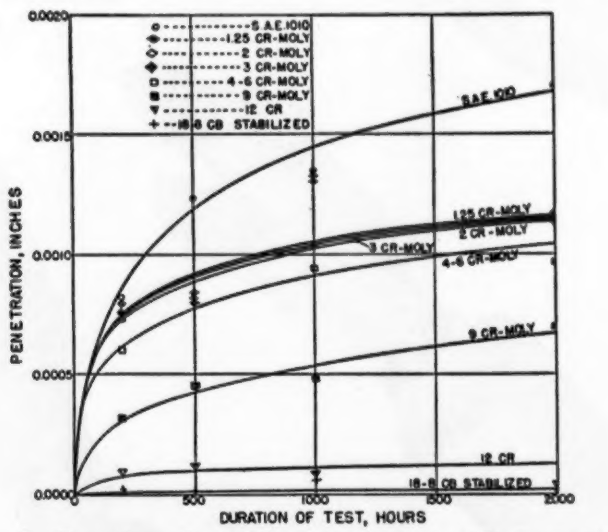

Fig. 2—Corrosion of steel bars in contact with steam at 1100 F for 200, 500, 1000 and 2000 hr.

[1] Head of School of Mechanical Engineering, Purdue University.
[2] Associate Professor of Mechanical Engineering, Purdue University.
[3] Dean of Schools of Engineering and Director of the Engineering Experiment Station, Purdue University.
[4] Potter, A. A., Solberg, H. L., and Hawkins, G. A., "Investigations of the Oxidation of Metals by High-Temperature Steam," *Transactions, A.S.M.E.*, 59, 725 (1937).

Fig. 1 shows the effect of time on extent of corrosion with steel tubes of different compositions in contact with steam at 1100 F for 100, 200, 500 and 1000 hr, and Fig. 2 the results with a number of different alloy bars in contact with steam at 1100 F for 200, 500, 1000 and 2000 hr. In all cases the corrosion rate was most rapid during the first 100 hr after which the layer of corrosion products retarded the rate of oxidation. In general, the corrosion was found to decrease as the chromium content of the steel increased and high-chromium steels were practically corrosion-resistant.

Fig. 3 represents the relative corrosion results with cast steels in contact with steam at 1200 F for 570 hr. In general, the corrosion of cast-steel specimens was not materially different in amount from that of the rolled steel specimens.

Further tests with the special alloys, Stellite, Hastelloy, Colmonoy and Lamite, showed all to be extremely resistant to steam corrosion.

Effect of Temperature Changes

Specimens of five different unstressed steels were placed in contact with superheated steam at a steady temperature of 1200 F for 500 hr. At the end of this period three specimens of each steel were removed and stripped electrolytically in order to measure the loss in weight due to corrosion. One-half of the remaining specimens were held at 1200 F, with sudden cooling to room temperature in nitrogen and heating again to 1200 F every 100 hr until the total time in contact with 1200 F steam was 1200 hr. The remainder of the specimens were treated similarly except for a 50-hr cooling cycle. Specimens were removed after 700 hr and also at the end of the test, in order to measure the extent of the corrosion.

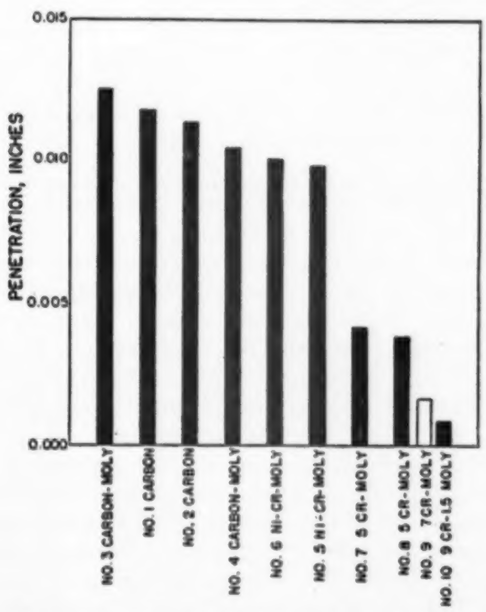

Fig. 3—Corrosion of cast steels in contact with steam at 1200 F for 570 hr.

The first visible evidence of extensive cracking of the scale occurred after a total exposure to steam of 700 hr. The result of visual observation during the test indicated that the layer of corrosion products is thinner and more brittle as the chromium content increases up to 5 per cent. An examination of the specimens indicated that the scale on the low-carbon-steel specimens was very thick, porous and, in spite of the severe temperature shocks, spalled only slightly as compared to the 4–6 Cr steel. The 2 per cent Cr steel spalled less than the 3 per cent Cr steel while the third layer of scale was cracking in the 4–6 per cent Cr steel at the end of 1200 hr.

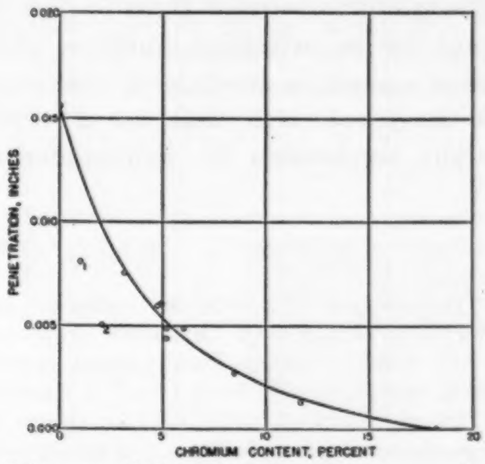

Fig. 4—Influence of chromium content on corrosion during intermittent operation

Little scale formed on the 9 per cent Cr steel and a microscopic examination of the surfaces at the end of the test failed to show evidence that the scale had cracked or checked.

Fig. 4 shows the influence of chromium content on corrosion of steels during intermittent operation at 1200 F for 1300 hr.

Conclusions

1. The resistance of alloy steels to high-temperature steam is greatly influenced by the amount of chromium present. Alloy steels containing 7 per cent or more of chromium are very resistant to corrosion produced by steam at temperatures up to at least 1400 F. The 18–8 stainless steels showed practically no corrosion when subjected to steam at temperatures up to 1400 F.

2. The corrosion rate is rapid during the first 500 hr of testing and then gradually diminishes as the time of exposure to the steam continues.

3. Steam temperatures greatly influence the corrosion of steels. Except for steels containing 7 per cent or more of chromium, the corrosion rate increases very rapidly at temperatures in excess of 1100 F.

4. The steels tested may be grouped into three general classes according to the type of scale formed. The first group consists of low-carbon steel, Carbon-Moly and the low-chromium steels which are covered with a thick, porous, tightly adhering scale. The scale which forms on the steels of the second group, that is, the 4–6 Cr steels and the 2 Cr-Moly-Al-Si steel, is very brittle and easily flakes off under fluctuating temperatures. The third group consists of steels having a chromium content of 7 per cent or more upon which a very thin non-porous tightly adhering scale is formed.

5. Scale formed on the inner surface of a tube does not flake off as readily as the scale which has formed on the outer surface of a tube.

Steam-Flow Characteristics of Extraction Turbines

By H. E. MORGAN
De Laval Steam Turbine Co.

The relations between throttle flow and output for an extraction turbine, under various operating conditions, are shown and compared with that for a typical straight condensing or non-condensing unit.

THE performance of a straight condensing or non-condensing turbine can be shown graphically as throttle flows at various loads plotted against output, which locates the "Willans Line," a substantially straight line from no load to full load for almost all turbines, regardless of type, as in Fig. 1. A steam turbine is ordinarily designed to develop its highest efficiency at full load, but to have capacity to carry 25 per cent overload at improved generator power factor.

A single automatic extraction turbine consists of a high-pressure section and a low-pressure section, each having its own admission control valves. The high-pressure valves control all steam going to the turbine, or "throttle steam," while the low-pressure admission (extraction) valve controls the steam flow to the low-pressure section in such manner as to maintain a fixed pressure at the extraction nozzle.

Guarantees of steam rate for an automatic extraction turbine-generator are invariably made on either a straight condensing or straight non-condensing performance, obtained with no extraction but with the extraction valve wide open, that is, not functioning to maintain the extraction pressure. This non-extraction performance

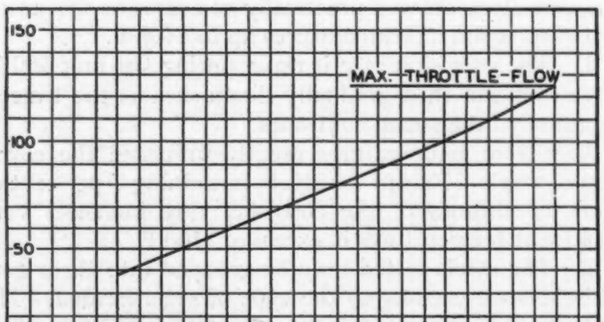

Fig. 1—Throttle flow vs. output (per cent of load), or Willans Line, for a steam turbine

guaranteed for an automatic extraction turbine will not differ much from that for a straight condensing unit of the same capacity and designed for the same steam conditions.

The complete performance of an extraction turbine can be represented by a chart such as Fig. 2, in which the output is expressed in per cent of rated capacity and the throttle flow in per cent of that at full load without extraction. The line labeled *O* represents the "zero extraction" performance of the turbine, no steam being extracted but the extraction valve acting to hold extraction pressure at the bleed connection.

The guaranteed steam flows for non-extraction, with the pressure at the bleed point varying with the load, that is, with the extraction valve wide open, are also plotted as a broken line on Fig. 2. This line intersects the zero extraction line at full load, while at partial

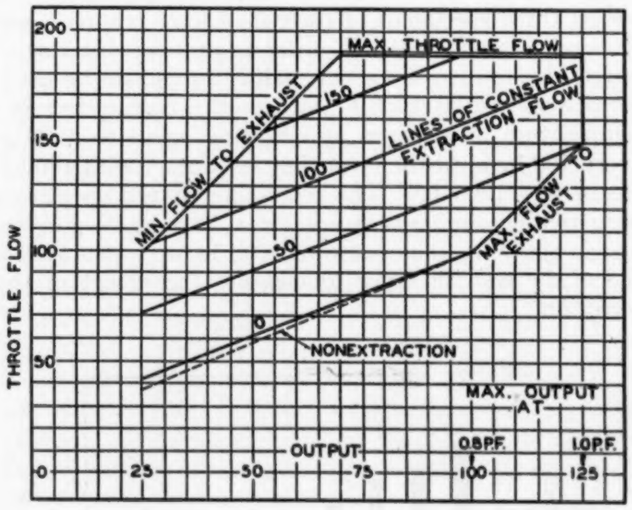

Fig. 2—Throttle flow vs. output curves (per cent of load) as modified by various rates of extraction

loads the throttle flow for non-extraction is less than for zero extraction. The reason for this is that the low-pressure end of the turbine has been designed for the steam flow which at full load, non-extraction with the extraction valve wide open, will give the extraction pressure required. If the steam flow through the low-pressure end of the turbine is decreased, as at partial loads, the absolute pressure at the extraction point would decrease in proportion to the steam flow if it were not for the action of the extraction valve, which throttles the steam to maintain the required extraction pressure. This throttling loss occurs when operating with zero extraction, but not when operating non-extraction.

When steam is extracted from a turbine carrying a given load, the throttle flow must increase, but the increase is not equal to the amount extracted. For a given turbine and set of steam conditions, the increase in throttle steam over that required for zero extraction will bear a constant ratio to the amount extracted. This ratio is called the extraction factor. As the extraction pressure is raised from exhaust pressure to inlet pressure

by extracting at points of progressively higher pressure, the extraction factor increases from 0 to 1.

The line labeled "Minimum Flow to Exhaust" represents the performance when all steam entering the throttle, except the cooling steam, is extracted. The line "Maximum Throttle Flow" represents the maximum flow which the high-pressure section can pass when the turbine is operated with its normal steam conditions. The corresponding limit for the low-pressure section is the one titled "Maximum Flow to Exhaust." The turbine can operate in the region to the right of the maximum flow to exhaust limit, but will not then maintain normal extraction pressure. For any given load the flow to exhaust is maximum at zero extraction, so that the maximum flow through the exhaust section for which the turbine must be proportioned is determined by the maximum load to be carried with minimum extraction.

Fuel Burned by Utilities

According to Government reports the electric utilities consumed during August 5,478,062 tons of bituminous coal (an increase of 4.9 per cent over July), 288,975 tons of anthracite (an increase of 6 per cent over July) and 1,783,283 bbl of fuel oil (an increase of 10.3 per cent over July). Gas consumption rose 11.5 per cent to 21,422,180 mcf. Stocks of coal on hand also increased and were 10.912,080 tons of bituminous coal and 1,357,305 tons of anthracite, as of September 30. It was estimated that stocks of bituminous coal were sufficient for 62 days.

Over 2,000,000 Kw of New Capacity Scheduled for Remainder of 1941

THE Federal Power Commission issued a report on September 17 showing that the gathering momentum of the defense program called upon power sources throughout the United States to supply 20 per cent more electric energy in June 1941 than was required in June 1940. The new report, the eleventh in the Commission's series on "Electric Power Requirements and Supply in the United States," also shows the probable demand for electric power in each area of the country for the remainder of 1941 and for 1942 and 1943 to meet the power needs of the accelerated defense program. The following tabulation shows percentage increases of energy requirements and peak demands supplied by Class I systems (all utility systems whose annual net energy for system use is in excess of 50,000,000 kw-hr) during each of the first six months of this year over corresponding months of 1940:

	Percentage Increase—1941 over 1940					
	January	February	March	April	May	June
Energy requirements	12.5	11.3	16.4	15.5	17.7	19.5
Peak demands	9.3	10.0	12.5	11.0	13.8	13.0

It is pointed out that these figures are nation-wide averages and consequently fail to indicate the more rapid advances in power use experienced in a majority of the important war material areas. For instance, in two power supply areas, June 1941 energy requirements were more than 30 per cent above June 1940; in eight areas requirements rose between 25 and 30 per cent; and in eight other areas requirements increased between 20 and 25 per cent. Of the remainder, only eight areas showed increases of less than 10 per cent. The largest increase in June 1941 energy requirements over June 1940 was experienced in the Pacific Northwest where requirements rose 58 per cent because of the increased defense production of metals, especially aluminum, utilizing power from Bonneville. Power requirements for North and South Carolina rose 31 per cent and, despite the effects of the drought, Tennessee maintained an increase of 27 per cent over June 1940.

Peak Demands

Peak demands for June 1941 reported by utility systems throughout the country averaged 13 per cent more than June 1940, whereas in fifteen areas they were more than 15 per cent above June 1940, and six of these areas topped June 1940 by more than 20 per cent.

Estimates Still Claimed to be Inadequate

Sharp upward revisions with respect to both 1941 peak demands and peak month energy requirements were made by the utilities in June when compared with estimates made six months earlier. In commenting upon these revisions, the report says:

"Despite the fact that reporting systems, faced with power demands exceeding earlier expectations, have made upward revisions aggregating 1,367,437 kw and thus raised their estimates of 1941 peak demands to 31,211,313 kw, many systems have apparently given insufficient weight to the substantial load increases already experienced during the earlier and less productive stages

of the defense program. Although June demands in New England were 15 per cent higher than in June of last year, utilities in that area estimate that their demands for the peak month of 1941 will be only 9 per cent higher than the 1940 peak. Similarly, in western Pennsylvania and West Virginia, where demands in June topped last year's June demands by 21 per cent, utilities expect 1941 peak loads to exceed last year's by only 10 per cent."

2,000,000 Kw of New Generating Capacity

Additional new generating capacity totaling 2,180,115 kw is scheduled for operation during the remainder of 1941, according to the report. This new capacity, it is claimed, will be urgently needed in most power supply areas for the 1941 peak loads, most of which are expected to occur in December. New generating capacity placed in operation during the first three months of 1941 totaled 255,050 kw and during the second three months 507,850 kw.

"The utilities are making efforts to expedite the installation of scheduled new capacity," the report says, "and it is significant that many new generating units, previously scheduled for operation in the early part of 1942, have been rescheduled for operation by December 1941. However, a delay of but a few weeks in the installation of much of this equipment would mean that several hundred thousand kilowatts of new capacity would not be available for the expected system peak loads late this year. Furthermore, orders should be placed immediately for new generating units which will be needed for operation in the latter half of 1943 and in 1944."

Following are the net assured and installed capacities in kilowatts, as of June 30, 1941, for the country's Class I systems, with a summary of scheduled additions as of that date. New generating capacity included is that actually reported on order:

	Installed Capacity, Kilowatts (Nameplate Ratings)		Net Assured Capacity, Kilowatts	
Date	(1) Total	(2) Additions	(3) Total	(4) Additions
June 30, 1941	36,838,409		30,901,253	
Dec. 31, 1941	39,018,524	2,180,115	33,178,948	2,277,695
Dec. 31, 1942	42,114,774	3,096,250	36,267,178	3,088,230
Dec. 31, 1943	43,949,374	1,834,600	38,204,678	1,937,500
Dec. 31, 1944	44,484,374	535,000	38,649,678	445,000
Total scheduled additions		7,645,965		7,748,425

The totals shown above under column (1) are broken down by type of prime mover as follows:

	Fuel, Kilowatts	Hydro, Kilowatts
June 30, 1941	25,783,162	11,055,247
Dec. 31, 1941	27,346,012	11,672,512
Dec. 31, 1942	29,710,412	12,404,362
Dec. 31, 1943	31,065,412	12,883,962
Dec. 31, 1944	31,300,412	13,183,962

In commenting upon the above increases in assured capacities by the utilities since January 1, the report recalls that the 715,000-kw increase reported during the first three months of 1941 consisted principally of higher capacity values assigned to existing generating facilities or decreases in the reported necessary operating reserves, as only 247,000 kw represented new generating units or other improvements.

"Contrasted with this situation," the report continues, "the reported increase in assured capacities during the second three months of 1941, totaling 650,000 kilowatts, is the result of new generating units (about 500,000 kilowatts) and additional coverage of utility systems (about 70,000 kilowatts), with boiler additions and other improvements chiefly making up the balance."

BOOKS

1—Technical Dictionary

957 pages Price $5.00

An important feature of this dictionary, recently compiled by British editors, is the inclusion of both the English and American terminologies where these differ from one another. Special care has been taken to do this, and leading American authorities have been consulted. Here you can find, in an instant, exact definitions of many terms you may wish to know, scientific words that are new to you, or recently coined technical terms.

The reference contains hundreds of words not found in ordinary dictionaries. It will be useful both to the specialist who wants to be familiar with terms in other fields, and to the layman who wants to know the terms used most frequently in science, engineering and industry. It meets the demand for up-to-date information as no other reference does.

It is reported to be the most comprehensive technical reference in English, with more than 50,000 entries, covering in one compact volume all branches of modern science and industry. Among the most up-to-date dictionaries of its kind, it includes terms resulting from the most recent research. The definitions, written by foremost authorities, are arranged for quick reference. When a term is used in several branches, the definition is specific for each. It succeeds in bridging the language gap between many fields of science, giving in a single volume information found otherwise only by referring to numerous specialized sources.

2—Practical Mathematics

By G. M. Hobbs, J. McKinney and J. R. Dalzell

599 pages Price $2.40

This, the second edition, is devoted to the phases of mathematics most widely used in trade and in applied branches of engineering. It is intended for beginners and for those who wish to brush up on long-forgotten fundamentals with a minimum of time and effort.

The book covers addition, subtraction, multiplication and division as well as fractions, decimals, percentage, factoring, powers, roots, ratio and proportion, equations, formulas, graphs and logarithms. Illustrative problems, which are worked out and explained in detail, are practical ones such as would be encountered in the different branches of engineering. By the study of such problems the student learns mathematics as well as its application to the fields of business.

Supplementing the mathematical considerations there are many tables including weights and measures and numerous suggested problems and examination questions with the answers.

3—Applied Heat Transmission

By Herman J. Stoever

226 pages Price $2.50

This book is intended for both practicing engineers and students. It puts some of the more important data on heat transmission into readily usable form, and describes the common types of heat-transfer equipment and installation. Emphasis is placed on practical applications rather than on theory.

The first three chapters deal with equations required for the solution of elementary problems involving heat transfer by conduction, radiation and convection. Chapters IV and V contain many charts and tables by means of which convection coefficients and the pressure drop values may be quickly and easily determined. The last two chapters are devoted to a description of the more common types of heat-transfer equipment and the kinds of insulation used in industry. Equations for calculating the thickness of insulation required for special conditions of industrial importance are given in the last chapter, together with the application of these equations, which is also demonstrated by the solution of numerical problems. This is a practical book and is amply illustrated with many drawings, charts and halftones.

4—1940-41 Standards on Coal and Coke

135 pages Price $1.25

This volume is issued under the auspices of the American Society for Testing Materials' Committee D-5 on Coal and Coke and combines in convenient form all the A.S.T.M. tests, definitions and specifications for coal and coke. Four items in the book cover sampling; other items include two grindability tests and other procedures, tests for size (anthracite), sieve analysis (crushed bituminous), cubic foot weight and a proposed agglutinating value of coal. Specifications for coals by rank and grade are also included, together with a section devoted to coke.

5—Heating, Ventilating, Air Conditioning Guide for 1941

1144 pages Price $5.00

The new 1941 edition of The Guide published by the American Society of Heating and Ventilating Engineers, comprises 46 chapters of technical data, much of which has been revised and rewritten to include the latest authoritative information available. A new chapter on the Thermodynamics of Air and Water Mixtures is presented, and in addition to the Bulkeley Psychrometric Chart a new Mollier Diagram for Moist Air is included for use in analyzing air conditioning processes. Chapters on Cooling, Dehumidification and Dehydration, and Refrigeration are also entirely new.

New data on solar heat transmission through walls, roofs and glass blocks will be found in the chapter on Cooling Load, and curves showing measured heat flow into structures replace the theoretical analysis given in previous editions. Information on buses and automobiles is included and reference made to air conditioning of ships and airplanes.

6—Applied Chemistry for Engineers

By Eric S. Gyngell

328 pages Price $4.00

This new book deals with the chemistry of materials and processes used by the engineer. The information is predicated on a previous knowledge, on the part of the reader, up to the Intermediate Engineering Standard of London University. However, the lack of this knowledge, in the judgment of the author, should not prove a serious handicap.

Fuels and combustion are treated fully, with chapters devoted to wood, peat and lignite, formation and classification of coal, coal analyses and constitution, gaseous fuels, liquid fuels, combustion and the like.

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Joint Fuels Meeting at Easton, Pa.

On October 30 to November 1, the A.S.M.E. Fuels Division and the A.I.M.E. Coal Division will hold a joint meeting at the Hotel Easton, Easton, Pa. This will be the fifth annual meeting sponsored jointly by these groups. A feature of this year's program will be two interesting symposiums—one on pulverized coal and the other on underfeed stokers. Following is the program in detail:

THURSDAY, October 30

9:30 a.m.

Address of Welcome, by Dr. William M. Lewis, President of Lafayette College

Response, by W. G. Christy, Chairman, A.S.M.E. Fuels Division, and J. E. Tobey, Chairman, A.I.M.E. Coal Division

Paper, "Application of Chemistry to Anthracite Mine Fire Problems," by O. W. Jones and C. S. Scott, U. S. Bureau of Mines

Paper, "Domestic Stoker Coal Research," by Walter Knox and J. D. Doherty, Koppers Co.

2:00 p.m.

Symposium on "Adjustment of Pulverized Fuel-Burning Equipment;" contributions by Henry Kreisinger, Combustion Engineering Company; A. C. Foster, Foster Wheeler Corporation; F. G. Ely, Babcock & Wilcox Company; and Ollison Craig, Riley Stoker Corp.

6:30 p.m.

Informal Dinner—Professor Paul B. Eaton presiding, with motion pictures of anthracite combustion on small retorts.

8:00 p.m.

Symposium on "Adjustment of Underfeed Stoker-Fired Equipment." Contributions by George P. Jackson, Combustion Engineering Company, illustrated with colored motion pictures by Otto deLorenzi; by J. S Bennett of American Engineering Company and by R. A. Foresman of Westinghouse Electric & Mfg. Co.

FRIDAY, October 31

8:00 a.m.

Breakfast meeting of Model Smoke Law Committee, A.S.M.E. Fuels Division; J. F. Barkley, Chairman

9:30 a.m.

Paper, "Effects of Changes of Moisture and Temperature on Mine Roof," by I. Hartmann and H. B. Greenwald

Paper, "Automatic Burning Control in Rotary Kilns," by W. E. Reaser

2:00 p.m.

Paper, "Performance of Industrial Chain-Grate Stokers," by J. H. Kerrick of Philadelphia & Reading Coal & Iron Co.

Paper, "Burning Pulverized Anthracite in Steam Power Plants," by C. H. Frick of Pennsylvania Power & Light Co.

6:30 p.m.

Banquet at Hotel Easton, Howard Eavenson, Toastmaster, and talk on "Better Utilization of Coal" by E. G. Bailey, Vice President of Babcock & Wilcox Co. Motion pictures of stoker-fired units will be shown by representatives of the Consolidated Edison Company of New York

Inspection trips scheduled for Saturday morning include visits to the Martin's Creek Plant of the Alpha Portland Cement Company; the Sandt's Eddy Plant of the Lehigh Portland Cement Company; the Milford Plant of the Riegel Paper Corporation; the Lansford Plant of the Lehigh Coal & Navigation Company, and a plant of the Pennsylvania Power & Light Company. Several of these plants have interesting fuel-burning installations.

NEW CATALOGS AND BULLETINS

Any of these publications will be sent on request

Bushings and Bearings

Merriman Brothers, Inc., has just issued a new bulletin (No. 41) dealing with its line of Lubrite self-lubricating bashings and bearings, washers and expansion plates. This is a well-illustrated 18-page presentation showing the details and commercial applications of Lubrite one- and two-piece bearings, thrust washers, expansion shoes, etc.

Blowoff Valves

The Yarnall-Waring Company has recently issued a two-color 24-page catalog, No. B-421, which gives complete details covering Yarway blowoff valves for working pressures up to 400 lb. This low and medium pressure group includes the slow operating seatless (sliding plunger) valve and the quick opening double tightening (flat-seat sliding disk) valve. These are offered singly or in tandem combinations to meet various operating conditions. Dimension sketches and tables are given and numerous illustrations show the construction, assembly and individual parts of this type of equipment.

Electrical Machinery

The "Catechism of Electrical Machinery" recently published by Fairbanks, Morse & Company is a comprehensive 48-page bulletin which presents in a simple way the important theoretical and practical features of common types of d-c and a-c motors, generators and control equipment. It is intended for those not familiar with electricity and its terminology. Simplified diagrams and halftones of F-M equipment illustrate the text and a back-page index gives a direct reference to each topic discussed.

Expansion Joints

The outstanding features of the Yarway gun-pakt expansion joint, described in bulletin EJ-1908 recently received from the Yarnall-Waring Company, is the use of a fixed gland ring with special attachments by means of which the packing may be forced into the stuffing box while the joint is under pressure. Many installations, assembly and cut-away views are given and three pages are devoted to dimension sketches and tables.

Boiler Water Treatment

An 8-page bulletin issued by the Water Treatment Company of America describes its supplementary boiler water treatment service for soda ash, lime and Zeolite water coagulants, known as Bearite-16. It is claimed that the organic colloids which comprise this product combine with as much as 20 times their weight of scale, forming a fine non-adhering sludge which does not pack and which is easily blown out; and that all scale, rust and corrosion may be removed in one-fourth of the time required by other methods.

Deaerators

The Cochrane Corporation has issued a new 36-page catalog which gives a comprehensive description of various types of deaerators. These include tray-type deaerators, atomizing deaerators, deaerating hot water generators and cold water deaerators. Three-color diagrams illustrate the operating features of the Cochrane deaerator which is further clarified by photographs and cut-away sectional views. Flow diagrams and installation pictures accompany a description of certain power-plant units and special pages are devoted to various designs constructed to meet space limitations and operating requirements. Details of accessory equipment are included together with a supplementary appendix on corrosion control and pH control.

Draft Gages

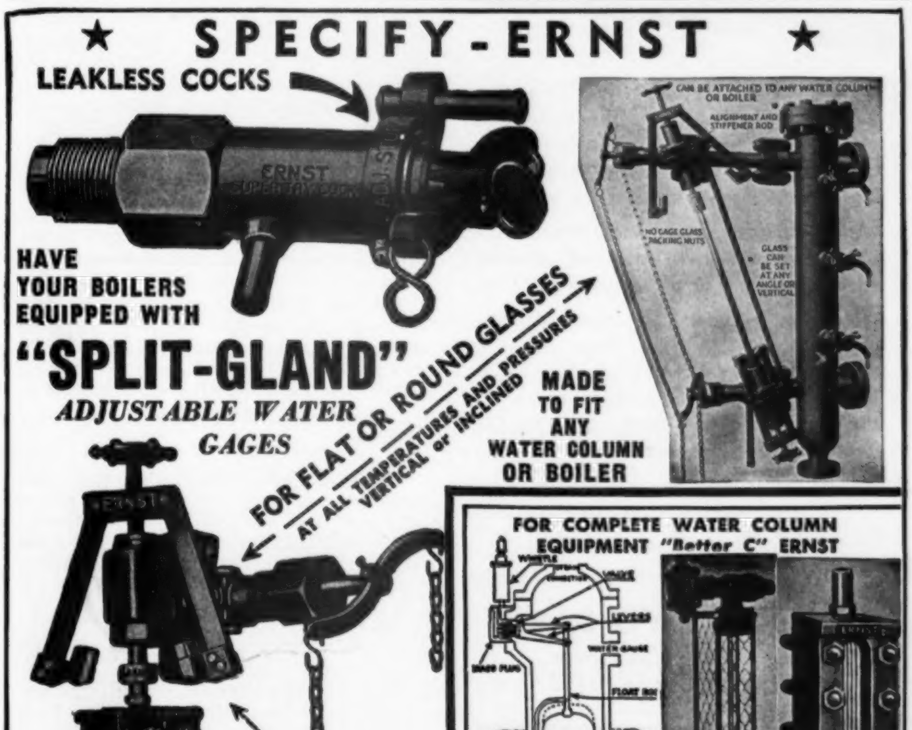
The Hays Corporation has issued a 20-page bulletin dealing in an informative way with questions pertaining to draft—what it is, how it is measured, where to measure draft and pressure, and how to install draft gages. The booklet is attractively printed in two colors and well illustrated.

Flow and Level Meters

The Brown Instrument Company has issued a 16-page catalog, No. 2204, covering its line of flow and liquid-level meters. The design and special features of these instruments are described and illustrated and schematic diagrams show special applications and general mounting dimensions.

Industrial Plant Heating

A 16-page bulletin, HR-1, has been issued by the L. J. Wing Mfg. Company describing its line of revolving unit heaters. Air drawn from the ceiling zone passes through heating elements and is projected through slowly revolving discharge outlets to the working level. Complete engineering data are given in this bulletin which is well illustrated with line drawings and halftones.



Marine Valves

A new 12-page catalog of cast iron and forged steel valves for marine service has been issued by The Edward Valve and Mfg. Company. This two-color bulletin contains pertinent data on steel stop valves, check, blow off, stop-check valves, etc. Each type is illustrated with cross-sectional drawings and pressure rating tables and dimension and weight tables are also given.

Steam Sample Degasifier

The corrosion from oxygen which is produced through dissociation of steam and water in contact with high temperature surfaces has been observed; the hydrogen produced is inert and escapes with the steam. As the oxygen combines with the boiler metal immediately, the amount of dissociation can be measured only by evaluating the hydrogen present.

Equipment has been designed by the Cochrane Corporation for the collection of such hydrogen samples, and the principle of the apparatus and the mode of operation are completely described in a 4-page bulletin (Publ. 3020) recently received.

Thermocouples

A new 32-page thermocouple data book and catalog has just been issued by the Wheelco Instruments Company, and it is believed to be the most complete compilation of data ever published for thermocouple users. It contains such information as temperature conversion tables, millivolt tables, pipe and wire sizes, wire resistances, recommendations for checking thermocouples and pyrometers, how to construct thermocouples, etc. Descriptions and prices are given on the company's complete line of thermocouples and accessories. The bulletin (No. S2-3) is illustrated and the information given is presented in a concise manner.

Water Treatment

D. W. Haering & Company, Inc., has just published a 48-page booklet of articles on scale, corrosion and water-treatment problems. Profusely illustrated, this pocket-size booklet provides important information including tables, charts and graphs on water problems occurring in cooling systems, hot-water systems, boilers and return systems including special data on corrosion inhibitors, scale preventives, protective coatings, proportioning equipment and refrigerating brine problems.

"Cooling Waters" is the title of another 46-page booklet received from D. W. Haering & Company comprising a group of articles on scale, corrosion and living organisms in cooling system operation, reprinted from two well-known trade journals. Subjects covered in this authoritative bulletin include experimental methods of studying cooling system problems, discussion of causes and prevention of corrosion of both steel and copper alloys, and microbiological deposits. The booklet is profusely illustrated with charts, tables and halftones.

Personals

Robert H. Barclay recently resigned as Regional Director of the Federal Power Commission, New York, and has joined The J. G. White Engineering Corporation as electrical engineer in charge of the Division of Electrical Engineering.

S. E. Tray has been appointed acting manager of the Feedwater Treating Department of the Allis-Chalmers Mfg. Company succeeding Otto H. Falk, Jr., who has resigned.

Edwin A. Wert has been elected vice president of Blaw-Knox Company in charge of engineering and sales of the Power Piping Division.

J. H. Schenck has been made manager of the Detroit office of The Dampney Company of America, replacing C. M. Boling who is now on active duty with the Navy Department as a lieutenant commander.

John A. O'Brien was elected vice president of Johns-Manville Sales Corporation on October 1 and will continue his duties as general sales manager of the power products and industrial department.

Herbert A. Cohn, formerly of the factory service division of Westinghouse Electric & Mfg. Co., has been appointed steam superintendent responsible for all boiler plant and heating installations in connection with building projects of the company.

Dr. Erich Leib of Combustion Engineering Company has been engaged to give a course in advanced Thermodynamics at the Stevens Institute Graduate School, on Monday evenings beginning in February.

Obituaries

William LeRoy Emmet, consulting engineer of the General Electric Company died on September 26 at Erie, Pa., at the age of 82. He was well known for his contributions to the fields of power generation and ship propulsion, particularly in development of the mercury boiler and turbine and turbine-electric drive for ships.

Lacy H. Morrison, Editor of *Diesel Power* and *Diesel Transportation*, died of a heart attack on September 20 at Port Washington, L. I. He was long an outstanding authority on diesel engines and the author of several books on the subject.

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